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SOME OBSERVATIONS ON CARCASS QUALITY IN THE BACON HOG

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In connection with recent swine feeding experiments conducted at the University of Alberta an attempt has been made to study the influence of certain feeding and management practices on the resulting carcasses from the standpoint of dimensions and proportion of fat and lean. Such practices as indoor and pasture feeding, the feeding of various protein supplements, and varying the amount of protein in the ration have been related to certain features which are regarded as being significant as indications of carcass quality. It is not the object of this particular paper to discuss the results secured from these experiments in terms of the effect of the factors mentioned on the resulting product but rather to make some observations on certain trends that were noted and difficulties that were encountered as carcasses and cross-sections of carcasses were examined in detail.

METHODS OF DETERMINING CARCASS QUALITY

In appraising carcass quality in connection with these experiments two main procedures were followed. All carcasses were graded and measured by packing plant employees and officials of the Dominion Live Stock Branch according to Advanced Registry Standards. This treatment yielded data regarding such essential principles as length of side, depth and uniformity of back fat, belly thickness, percentage of shoulder, ham, and middle, as well as other details.

Following the grading of the carcasses and examination on the basis of Advanced Registry Standards a cross section was removed from the right side of each carcass and preserved for the purpose of making more detailed observations. These sections, averaging two inches in thickness, were removed immediately posterior to the last rib and extending through the entire side. They presented a cross section picture of the side illustrating the covering of fat on back and belly, the "eye of lean" or longissimus dorsi muscle, and also the external oblique, internal oblique, transverse abdominus and a small portion of the rectus abdominus muscles, or collectively a group of muscles commonly referred to as the "streak muscles." The inter-muscular fat was also clearly defined. The sections after removal from the carcass were frozen until measurements could be made. When measurements were to be made on these sections, they were pratially de-frosted, and then cut in two, thus exposing a smooth firm surface from which tracings could readily be obtained. Tracings were made on "frosted"

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glass with a common lead pencil and transferred to paper from which measurements were made by use of a planimeter. The total area of the entire section was registered and individual determinations on all muscles were made. From these planimeter readings the percentage of fat and lean and the percentage of such individual muscles as the "eye of lean" was determined. It was felt that this method when followed consistently would form a basis for studying gross differences in details which collectively constitute carcass quality.

In alloting the pigs which were used in the experiments to which reference has been made, the "litter mate" plan was followed. This means that all the animals in one lot were litter mates of the animals in the other groups in the experiment. This plan has been discussed recently by Dunlop (*1*) in the light of Cambridge experiments. When such features as those involving carcass differences are under consideration it is essential that as far as possible genetic differences between experimental groups be avoided. It would be expected that animals from the same litter, and thus of the same genetic make-up, would react with a minimum of variability to the particular experimental condition which might be imposed.

In studying the data obtained from carcass measurement it was noted that a serious problem arose in that a wide range was found for any one detail between the various animals in an experimental group. This range might be so wide in certain cases that differences induced by a particular experimental factor might be overshadowed. When this observation was made the group data were rearranged on the litter basis, and a comparison made of a series of litters in order to observe the variability between litters and within litters as compared with the variation between experimental groups and within experimental groups.

In one of the experiments five litters were involved, and by way of illustrating what was noted the data are submitted in Table 1.

TABLE 1.—MEASUREMENTS AND CARCASS PERCENTAGES OF FIVE LITTERS

	Litter no 1 (inches)	Litter no. 2 (inches)	Litter no. 3 (inches)	Litter no. 4 (inches)	Litter no. 5 (inches)
Average length of carcass	31.7	31.4	31.95	30.85	31.55
% shoulder of carcass	27.88	27.8	28.18	28.10	29.02
% ham of carcass	22.38	22.1	23.22	22.5	23.8
Av. depth shoulder fat	1.75	1.875	1.725	1.95	1.575
Av. depth back fat	1.20	1.275	1.075	1.35	1.00
Av. depth loin fat	1.60	1.525	1.575	1.70	1.40
Av min. belly thickness	1.03	1.00	.95	1.04	.85
Av. max. belly thickness	1.85	1.85	1.725	1.85	1.70

Litters 2 and 3 were purebred Tamworths while the other three litters were purebred Yorkshires.

The average live weights of all pigs ranged between 215.2 and 222.4 pounds.

The data shown in the Table 1 indicate rather a marked difference between litters in connection with certain important features of carcass quality.

The difference in average length was not noticeable, and the relation between weight of ham and shoulder based on average figures was fairly uniform as between litters. Depth of back fat and thickness of belly, however, were features which varied widely. The point of special concern in this connection is the influence of such a litter as no. 5 in depressing the average thickness of belly and back fat within lots where these pigs were distributed.

The degree of variability between animals, whether the data were considered on the experimental lot basis or by litters was equally great. Such a factor as length of side showed differences as great as two inches in each case. The fat measurements and belly measurements also showed great variations between individuals. However, it was noted that litter trends were in evidence to a significant degree. Certain litters showed a thick belly while other litters were lacking in belly thickness. The same was true in connection with fat covering. From this point of view litter mate distribution within experimental groups for this type of experiment would appear to offer some advantage in aiming at uniformity as compared with a random distribution of pigs without regard to the genetic factor.

In addition to arranging the data derived from carcass weights and measurements by litters a similar plan was followed in connection with the figures secured from planimeter measurements on the cross sections from the carcasses. These figures are indicated in the Table 2.

TABLE 2.—MEASUREMENTS FROM CARCASS CROSS SECTIONS

	Litter no. 1 (sq. in.)	Litter no. 2 (sq. in.)	Litter no. 3 (sq. in.)	Litter no. 4 (sq. in.)	Litter no. 4 (sq. in.)
Av. total area of cross section	27.85	28.21	24.52	28.36	24.35
% lean in cross section	33.25	35.76	40.12	32.35	45.78
Av. area "eye of lean"	3.84	4.36	4.42	4.15	5.00
Av. area "large streak muscle"	1.55	1.60	1.71	1.69	1.75

The figures in the above table show trends similar to those found in Table 1. It is to be noted that litters 3 and 5 showed a definitely higher percentage of lean than did any of the other litters. Back fat measurements in these litters were low. Likewise litter 4, having the lowest percentage of lean, showed the highest back fat measurement. The "eye of lean" and "streak muscle" were appreciably larger in litter 5 than in the others. In other words, the pigs in this particular litter were lean as compared with the others. Here again it is apparent that such litters as no. 1 and no. 5 would exert a decided influence in raising or lowering the average percentage of lean in groups in which they were distributed. As was the case in connection with gross carcass measurements, the cross section determinations showed a wide variation between individuals within a litter. However, this variation was not as great as between individuals in the experimental lots. A survey of litter data from other experiments than the one from which specific examples have been drawn showed similar trends. There was a tendency for litter mates to show a definite trend with respect to what may be regarded as an inherent potentiality in the

matter of fat or lean production as assessed by "depth of back fat" or "size of eye of lean." As has already been mentioned this observation lends support to the practice of litter mate distribution in connection with carcass quality experiments, and its significance with regard to breeding practices is apparent. If certain strains possess the ability to produce carcasses of high lean content with sufficient finish, it would seem feasible to pursue a policy of intensive breeding with a view to reducing the degree of variability within litters to a minimum. In fact this would seem necessary if reliable information from carcass quality experiments is to be secured, and in the broader field, if there is to be a uniformity in type and quality of commercial carcasses.

CARCASS CORRELATIONS

In connection with a mathematical treatment of measurements secured from numerous carcasses an attempt was made to ascertain whether or not any correlations existed between some of the more important features involved in carcass quality. Findings of this type should be of value not only to the buyer and processor of pork products but also to the producer and breeder. There are certain body and carcass characteristics which are readily assessable while the animal is alive. Length may be regarded as one of these. While it may not be possible to determine the exact length of carcass which may be yielded by the live animal, nevertheless a comparative judgment can fairly readily be made. The same thing is true of the comparative proportions of ham and shoulder. There are some more or less intrinsic features, however, such as size of "eye of lean" or proportion of lean meat to fat which cannot be determined by usual inspection. If, therefore, some significant correlation could be found to exist between these two types of carcass qualifications, for example, length and percentage of ham or thickness of belly, the grading of live animals might be more informative and a more satisfactory selection of breeding stock might be made.

In connection with the carcass measurements which were utilized in this study, the averages obtained from 350 carcasses are worthy of note. Of the 350 carcasses, 200 were from pigs slaughtered under the Advanced Registry Scheme and 150 were from pigs used in experiments at the University of Alberta in 1934 and 1935. These pigs would perhaps represent a fairly high grade sample of "selects" with a small percentage of "bacons." The average measurements of a number of features are shown in the Table 3.

TABLE 3.—AVERAGE MEASUREMENTS ON 350 CARCASSES

Length of carcass	30.8 inches
Depth of shoulder fat	1.825 inches
Depth of back fat	1.15 inches
Depth of loin fat	1.49 inches
Percentage ham of carcass	23.94
Percentage shoulder of carcass	28.54
Percentage middle of carcass	47.52

The figures in the Table 3 indicate that the ideal of an even distribution of back fat is difficult to attain. The covering on the shoulder is heavy as compared with the other measurements of fat along the back and loin. Careful selection of breeding stock on the basis of carcass studies is evidently required.

A point of special interest in connection with Table 3 is the relationship between the percentage of ham and the percentage of shoulder. It

will be noted that the percentage of shoulder is 4.6% greater than the percentage of ham. In no case was there a carcass showing equal proportions of ham and shoulder, the condition which is regarded as ideal. It would appear that the proportions of 50% middle, 25% shoulder and 25% ham on the basis of cutting practices followed are out of line with the normal anatomical development of the bacon hog as represented in the samples studied. In this connection Hammond's (*2*) finding regarding the development of the animal body is of interest. He points out that the development of the body is in a posterior direction, that is the neck and shoulders of a young animal are always large in proportion to the rest of the body. It may be that these pigs marketed at a light weight and early age (5 to 7 months) in relation to maturity have not yet attained a normal balance in body proportions.

Further averages were obtained on the detailed features of the carcass from 106 pigs. These are shown in Table 4.

TABLE 4.—DETAILED CARCASS MEASUREMENTS

Maximum belly thickness	1.877 inches
Minimum belly thickness	1.03 inches
Av. area of cross section	26.44 sq. in.
Av. area "eye of lean"	4.43 sq. in.
Av. percentage lean in cross section	37.60
Av. percentage "eye of lean" in cross section	16.46

It is to be noted that the average minimum belly thickness, as determined by a measurement in the flank area, was 1.03 inches. This deviates markedly from the maximum thickness in the fore belly area and may be regarded as decidedly marginal in relation to commercial requirements.

The percentage of lean in the cross sections averaged 37.60% and as has been mentioned already a wide variation was found between carcasses in this respect. This figure may be compared with those obtained by Mitchell and Hamilton (*3*) in their work at Illinois. They determined the percentages of lean meat, fat, skin and bone in the carcasses of pigs which had been subject to various methods of feeding and found that the carcasses from short, overfinished pigs contained 42.3% lean while those from the longer pigs carrying less finish contained 47.1% lean. The difference between the figure of 37.6% and the Illinois figures is explainable on the basis of the fact that with the exception of the "eye of lean", which makes up 16.46% of the whole, there are very few large areas of lean in the sections from the middle. The individual muscles in this area are interspersed with layers of fat, a condition which is not found to the same extent in other parts of the body.

A number of correlations were calculated from the data obtained on the 106 carcasses secured from the 1934 and 1935 experiments. Correlations were worked out between the "percentage total lean" in the carcass sections and a number of details such as length of carcass, depth of fat, belly thickness, and shoulder and ham percentages. The only definitely positive correlation (+.8802) found was between the percentage of lean meat and the percentage of ham. As the ham tended to increase in size in proportion to shoulder and middle the proportion of lean meat in the side increased.

No consistent relationship was found to exist between back fat measurements and percentage of lean in the section.

Correlations were also worked out between the percentage "eye of lean" and certain carcass measurements. In this connection a high positive correlation (+.9523) was found to exist between the percentage "eye of lean" and the "percentage of ham." This suggests that a larger percentage of ham was associated with a larger "eye of lean" and more extensive muscling generally in the cross sections which were studied. Such an arrangement seems reasonable on the basis of the anatomy of the animal, since the longissimus dorsi muscle, or the "eye of lean" is the only large muscle which connects the hind quarters with the fore quarters and the central portion of the body. If this relationship holds true generally, a full, muscular or "meaty" ham might be used as an index of muscle or lean development throughout the carcass.

Since length is a feature of carcass quality which can be estimated within reasonable limits by visual inspection of the live animal, any correlation between this anatomical aspect and other features of carcass quality would be of interest. Correlations were determined as between length and depth of back fat, belly thickness, and shoulder and ham percentages. No correlation was found to exist between carcass length and the features mentioned. The commonly expressed opinion that the longer pig is more likely to yield a thin belly cut than the short pig was not found to hold true in the case of the carcasses studied.

The observations and measurements which were made on the entire carcasses and carcass sections brought out quite clearly the fact that pigs fed and managed similarly and of very close genetic relationship vary considerably anatomically and particularly with regard to muscle development. The size of the large muscles may vary appreciably and the size and distribution of the smaller muscles which constitute the "streak" may differ widely between individuals of the same age and weight. It is realized that the various physiological processes which are involved in the production of a bacon hog carcass may not lend themselves to any measure of standardization by the breeder, but it is believed that the constructive development of high class commercial pigs and the attainment of a high degree of uniformity can best be carried out by closely linking selections on the hoof with detailed carcass analysis. The importance of feeding and management practices in relation to the quality of the finished article is not overlooked, but when consideration is given to the variability which occurs among closely related pigs similarly managed the importance of the breeding aspect becomes clearly manifest.

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THE EXAMINATION OF WHEAT SEED TO DETERMINE THE DISEASE FACTOR[1]

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The purpose of this paper is to give a brief account of methods used in the examination of wheat seed samples for disease, with special reference to samples collected in Saskatchewan. The term "disease" is employed here to designate any abnormality of the seed including the various discolorations and blemishes of either parasitic or non-parasitic origin. Some seeds merely serve as carriers of disease producing organisms, while in other cases they are specifically affected. The accurate determination of diseases within a seed sample has been of considerable help in efforts made to prevent the spread of certain maladies. Furthermore the effective use of seed treatments presupposes a knowledge of seed born parasites.

Chen (*1*) made a comprehensive study of internal fungous parasites of the seeds of crop plants, giving an extensive review of the literature. This was one of the first systematic studies on seed diseases. Heald (*6*) investigated the question of the relationship between spore load and the amount of bunt which appears in the crop. A rather complete outline of instructions for the examination of seeds for the identification of fungous pests has been given by Dorogin (*2*). It was suggested by Gentner (*4*) that seed parasites should be determined at the time the sample is examined for purity and germination. Orton (*10*) discussed the economic importance of seed-borne diseases as reported in surveys, especially of cereal crops, made in the United States. It has been suggested by Lobik (*7*) that the probable degree of infection of wheat with bunt could be estimated in a satisfactory manner by determining the amount of spore material on the seed. According to Hadfield (*5*) a scheme for the certification of seed wheat, to obtain seed as free as possible from seed-borne diseases, has been introduced in Canterbury, New Zealand. Doyer (*3*) in a recent paper proposed a classification of the various seed diseases of crop plants. A preliminary report on the systematic examination of a number of barley seed samples has been contributed by Mead (*8*).

A study of seed diseases of wheat was commenced in 1926 at the Saskatoon Laboratory and later investigations on barley seed troubles were started. In our work particular attention has been given to the technique of examination. A large number of samples collected or sent in have been examined each year.

A REVIEW OF THE TESTS EMPLOYED

Visual examination.—It is obvious that all samples should be examined carefully, perhaps with the aid of a magnifying glass, to determine conspicuous contaminations. In wheat samples the following may be readily observed: Ergot or other sclerotia, smut-balls, nematode galls, kernel discolorations as, smudge or black-point caused by *Helminthosporium sativum* and possibly other fungi, basal glumerot or bacterial black-point,

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scab or *Fusarium* mummies, frost injury, broken pericarps, pink, green, piebald, weathered and shrivelled kernels, weed stain, especially staining from Russian thistle. When bunt contamination is heavy the brush of the kernels will be distinctly darkened and such grains are often spoken of as being "tagged" with smut.

The visual examination is an exceedingly useful and practicable procedure. It should be considered as the first step in any scheme of seed testing for the determination of diseases.

Centrifuge test.—This is used to determine surface contaminations which would not ordinarily be detected in the visual examination. A quantity of seed is thoroughly shaken in water bringing the surface matter into suspension. The suspension is centrifuged, the clear water poured off and the residue examined with a microscope. If a blood-counter is used the approximate number of spores, for instance, in a cubic centimeter of suspension or for a gram of seed, may be determined. The centrifuge test will reveal various smut spores, conidia of *Helminthosporium* spp., *Fusaria* spp., and so forth, as well as miscellaneous fragments of mycelium. This test is considered very useful for seed examinations.

Sterile sand test.—A good quantity of coarse sand is used. A number of seeds are planted in the sterilized sand, contained preferably in flats, and watered with care. The seedlings are allowed to grow in the greenhouse for about ten days when they are removed and examined for lesions on the roots and coleoptile. This test will give the emergence (germination), seedling blight, and the percentage of seedlings showing lesions. It is then possible to make isolations from the lesions and the fungi can be identified.

This test is very useful for determining the general vigour of the seeds as well as the amount and identity of certain active parasites which they carry. For this purpose it is considered better than the usual blotter germination method, as it approximates soil conditions and is not so subject to the confusion arising from the growth of saprophytic fungi.

Sterile sand in glass tubes.—This is a modification of the above test. Glass tubes, one foot long, three-fourths of an inch in diameter and open at both ends are used. One seed is sown to each tube. At the end of the test the sand and seedling is drawn out of the tube with the aid of a filter pump. The root system and the shoot can be readily measured and examined for lesions.

Where possible this test is employed in preference to the ordinary sand method. It is considered particularly valuable in determining seedling root vigour.

Moist chamber test.—A moist chamber is suitably fitted with blotter paper and then sterilized. The seeds are evenly distributed on the moist blotter paper, being well spaced. Ordinarily the seeds were not previously surface sterilized or washed. In this way the miscellaneous contaminants were encouraged to develop and fruit. An incubation period of about eight days at 24° C. was sufficient to bring out conspicuous fungous growth.

This test gives a good indication of the quantity and character of the fungous flora in the sample, and is to some extent complementary to the sand test which gives an indication of some of the parasitic fungi present.

Plating on agar.—The usual method of determining the fungi on or in cereal seeds has been to plate them on an agar medium after a suitable surface sterilization. Surface sterilization with various fungicides may bring about many irregularities as pointed out by Mead (*9*). Although plating on agar may be desirable in certain cases it is felt that the moist chamber test and sterile sand test will give more satisfactory results. Plating is of greater assistance in the detection of bacterial parasites; although these may be determined in many cases by direct microscopic examination of fragments of tissues bearing lesions, in conjunction with a knowledge of the characteristic symptoms.

The writers have not found this test satisfactory for routine examinations.

Pericarp examinations.—The epidermis and underlying tissue can be readily stripped from wheat kernels after a short period of soaking. Then with proper staining or in many cases without staining, the extent of fungous invasion can be appraised. In this way one can frequently determine the fungi involved from the character of the mycelium. This method in our opinion, is not of much help in diagnosis.

Mature plant test.—This appears to be the only satisfactory test so far for determining the percentage of loose smut infection in seed samples of wheat and barley, and for confirming the presence of stripe infection of barley.

Several samples of wheat suspected of having loose smut were grown to maturity in the greenhouse and compared with similar samples grown in the field. The results indicate that the greenhouse test would give a good indication of the amount of infection to expect in the field.

NOTES ON SAMPLES EXAMINED

In 1926 eleven samples of Marquis wheat seed from various points in the prairie provinces were sown in sterile sand and the seedlings examined for lesions. Every sample produced some plants bearing lesions. The number so affected for each sample varied from 2.4 to 10.2%. *Helminthosporium sativum* was obtained from 0.6 to 5.6% of the lesions.

In 1928 a group of samples of wheat was examined by means of a microscopic examination and a centrifuge test. The former revealed in various samples, ergot sclerotia, smudge or fungous black-point, basal glumerot or bacterial black-point and piebald kernels. In one case 50% of the kernels had a break in the pericarp immediately over the embryo. The centrifuge test revealed balls and spores of bunt, and conidia of *H. sativum* and *Fusarium* spp. A mature plant test on one sample conducted in the greenhouse, gave 2.8% of loose smut.

During the same winter thirty-eight samples received from farmers were tested in sterile sand. Three samples produced seedlings free of lesions, while the remainder showed amounts ranging from 1 to 9.6%. Usually three hundred kernels were tested in each case.

In 1930 seven samples of Marquis were subjected to the following tests: visual examination, centrifuge, moist chamber, and sterile sand. The visual examination revealed one sample with 24% of smudge kernels, two showed 0.2% scab (these were from eastern Canada), one with 45%

frost injury, one with piebald kernels to the extent of 24% while the remainder showed miscellaneous discolorations in smaller amounts. The centrifuge test revealed bunt spores in two samples, *H. sativum* conidia in one, *Fusarium* conidia in one, and *Alternaria* in four samples. In the moist chamber test, germination ranged from 90 to 100%, while the percentage of mouldy kernels varied from 2 to 67. In the sterile sand test all samples revealed a trace of seedling blight except one, and 0 to 5% of the seedlings had severe lesions. One sample, No. 18, was particularly outstanding in these tests; it was practically free from discolorations or surface matter, had a perfect germination with only 2% of the kernels showing mould growth, and in addition revealed only slight lesions on 3% of the seedlings.

Later studies have been directed towards obtaining more information on vigour as measured by root development, using sterile sand in glass tubes. The total root length, for a given period, varied a great deal for the different samples of wheat tested. It would be of interest to know the cause of this and its significance. In the samples tested there appeared to be a negative correlation between the amount of abnormalities and total root length. The results, however, have not been consistent. An attempt has been made to compare greenhouse results with field tests especially in regard to yield, but unfavorable weather conditions so far have made the field data unreliable.

DISCUSSION

From the results obtained in an examination of a large number of wheat and barley seed samples it appears that certain tests are more useful than others. The more conspicuous contaminations or seed injuries can be determined in a macroscopic examination. The centrifuge test serves to reveal the remaining free contamination. This test should give one a fair indication of the amount of bunt to expect in the resultant crop. Furthermore, there appears to be no reason why this method could not be perfected as Heald (*6*) and Lobik (*7*) have suggested. The presence or absence of bunt in a sample should determine whether such a sample required treatment or not, providing other sources of contamination are kept in mind. Loose smut of wheat might be considered at this point. When spores of this fungus are found in examination of mounts from the centrifuge residue, they have some suggestive value in indicating possible infection in the crop from which the seeds were obtained. The sample may then be tested for loose smut if thought advisable; at present this can best be done by sowing a definite number of seeds and allowing the plants to mature in the greenhouse. The next important test is considered to be a germination test in sterile sand as this will reveal the germinability, vigour and the extent of seedling infections. If isolations are made from the lesions which appear on the seedlings, they will give an indication of the fungi present. In a test of this kind the influence of temperature is an important consideration. Our tests were conducted at approximately 24° C. but it was realized that further observations upon this point are needed. (The standard germination test still remains the best single technique for determining the general suitability of a sample for seed purposes.) The moist chamber test and the examinations of pericarp tissue will give additional information on the extent of fungous invasions in wheat seed. The testing of seed in sterile sand in glass tubes may have

some application after further investigations are made upon the significance of vigour.

It is evident from the results obtained in the examination of many samples over a period of years that certain contaminations and injuries are of common occurrence. It would appear also that the use of one or more simple tests should give one a fair indication of the extent and significance of the disease factor in wheat seed samples. The methods used for wheat would in general apply for the other cereals. Additional study should lead towards an improvement in technique and the development of a scheme of analysis suitable for routine practice.

SUMMARY

1. The literature dealing with the methods of examination of seed samples for the determination of seed-borne diseases is reviewed.

2. Most of the methods proposed are discussed especially in relation to the examination of wheat seed samples.

3. The results obtained, with wheat seed samples collected in Saskatchewan, show that a good indication of the disease factor may be determined by a systematic examination.

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Résumé

L'examen de la semence de blé pour déterminer les facteurs de maladie. P. M. Simmonds et H. W. Mead, Université de l'Alberta, Edmonton, Alberta.

Les auteurs passent en revue les ouvrages traitant des méthodes d'examen des échantillons de semence pour les germes des maladies portés par la semence. La plupart des méthodes proposées sont discutées, spécialement en ce qui concerne l'examen des échantillons de semence de blé. Les résultats obtenus sur des échantillons de semence de blé prélevés en Saskatchewan, montrent qu'un examen systématique peut fournir une bonne indication relativement au facteur de maladie.

A CONTRIBUTION TO THE KNOWLEDGE OF SUGAR-BEET INSECTS IN ONTARIO

A HISTORICAL REVIEW AND PRELIMINARY SURVEY OF THE INSECTS ASSOCIATED WITH SUGAR-BEETS

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This paper is designed to bring our knowledge of the sugar-beet insects of Ontario up to date and to record certain observations made during the past few years on the insects damaging sugar-beets or associated with the growing of this crop.

The work with sugar-beet insects at this laboratory has not been extensive. Until two years ago it consisted of the recording of insects sent in by growers or noticed on beets by members of the staff. During 1933, however, weekly collections of insects were made from a sugar-beet field. These were supplemented by collections from other fields at odd intervals during the season. The same type of collections were made in 1934.[2]

THE IMPORTANCE AND HISTORY OF SUGAR-BEET PRODUCTION IN ONTARIO

The average annual acreage grown to sugar-beets in Ontario for the period 1922-1931 amounted to 35,271 acres (*29*), with an average annual market value of $2,398,185. In 1932, 33,256 acres were grown with a market value of $1,745,939. Some sugar-beets are grown in every county in Ontario, but the main crop is produced for sugar production in the counties of Kent, Essex, Lambton and Middlesex. These counties in 1932 produced 30,319 of the total 33,256 acres grown in the province. Kent county alone produced 19,679 acres.

In these counties the sugar-beets are largely grown under contract to the Canada and Dominion Sugar Company which operates factories at Chatham and Wallaceburg. The total acreage is distributed over about three thousand farms. Each farm, therefore, grows about ten acres of beets a year.

Sugar-beet culture is not an old industry in Ontario's agriculture. The factory at Wallaceburg began operations in 1902, while the one at Chatham was erected in 1916. Both have been in continuous operation since. Sugar-beet growing on a large scale in the Chatham-Wallaceburg district has been continuous for the past thirty-two years.

A HISTORICAL REVIEW OF BEET INSECTS IN ONTARIO

This review deals with the published records of insects associated with the beet plant, including garden beets, sugar-beets and mangel-wurzel or mangel.

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[1] Entomologist.

[2] The field collections were made by Mr. W. E. Lindsay, while the laboratory work was done by various members of the staff. The work was done in co-operation with the Canada and Dominion Sugar Company, and it is desired to thank the following officers for their interest and aid: Mr. Henry Stokes, Dr. H. D. Brown, Messrs. R. E. Richards and C. Secord. The identification of many of the insects was made by the members of the Division of Systematic Entomology, Entomological Branch, Ottawa, and especial thanks are due to Dr. J. McDunnough, Mr. Stuart Walley and Mr. W. A. Brown for this service.

Cutworms of several species have been reported as injurious to beets. Gibson (*22*) discusses cutworms in general and mentions them as feeding on beets and other crops. *Euxoa ochrogaster* Gn., was reported by Gibson as injurious to beets in eastern Ontario in 1912 (*16*) and 1920 (*23*). A general account of the life-history and habits of this cut-worm is given by Gibson (*17*). *Euxoa messoria* Harr., and *Euxoa tessellata* Harr., were reported by the same author (*20*) as having destroyed the first sowings of garden beets in the Ottawa district in 1915. The last species was also destructive to beets and other garden vegetables in Eastern Ontario in 1920 (*23*). The life-history of this species is dealt with by Gibson (*17*) who states that beets and spinach are freely attacked.

The larvae of *Septis arctica* Bdv., are stated by Gibson (*17*) to attack spinach and other vegetables. *Graphiphora c-nigrum* L., according to Gibson (*17*), destroyed a field of mangels at Ancaster, Ontario, in 1914. *Peridroma margaritosa* Haw., according to Bethune (*2*), feeds on many plants including beets.

Scotogramma trifolii Rott., according to Fletcher (*14*), suddenly appeared in 1888 in central Ontario. It attacked mostly peas, but in the vicinity of Paris, mangels were also destroyed. Gibson (*17*), lists mangels and spinach among the host plants of the species in Ontario.

The zebra caterpillar, *Ceramica picta* Harr., according to Gibson (*20*), occurred in large numbers in Eastern Canada during the autumn of 1916. A number of crops were damaged including mangels. Caesar (*6*) reported the insect as feeding on sugar-beets in Ontario during 1917.

Gibson (*19*) and Baker (*1*) described the outbreak of the armyworm, *Cirphis unipuncta* Haw., in Ontario during 1914. The infestation was centred in the sugar-beet growing region. Many kinds of crops were damaged, but sugar-beets and mangels were fairly free from attack. Bethune (*2*) states that in Ontario many kinds of crops are eaten including beets, especially when the insect is abundant. Gibson (*18*) gives a detailed report of this insect and states that beets and mangels are among the food plants in Ontario.

Autographa brassicae Riley, is listed as feeding upon beets as well as many other host plants in Canada, by Dustan (*13*).

The greenhouse leaf-tyer, *Phlyctaenia rubigalis* Gn., has been reported by Gibson (*21*) on sugar-beets in the field. No definite locality is mentioned. Dustan (*13*) records the insect as feeding upon beets and spinach.

The European corn borer, *Pyrausta nubilalis* Hubn., has been reported by Spencer (*35*) as infesting sugar-beets. The larvae were infesting this crop when planted near corn fields. Marshall (*26*) investigated the host relationship of sugar-beets to the corn borer and found that they were infested by larvae migrating from fields of corn. Sugar-beets two hundred feet from corn fields were rarely infested. In certain rare cases, corn borer adults laid eggs on sugar-beet plants and the larvae were able to mature. Caesar (*7*) and Caesar and Thompson (*11*) record sugar-beets as a host of this insect to a very slight extent in Ontario.

Bethune (*2*), states that in Ontario the caterpillars of *Diacrisia virginica* Fab., sometimes eat the foliage of beets and spinach.

White grubs, *Phyllophaga* spp., were reported by Noble (*28*) as very injurious to sugar-beets in Essex county during 1916. The author observed infestations in Raleigh and Dover townships, Kent county, during 1931. This report was published by Ross and Caesar (*34*).

Flea-beetles are said by Bethune (*2*) to attack many crops in Ontario, preferring beets as a host plant. The hop flea-beetle, *Psylliodes punctulata* Melsh., has been observed damaging young sugar-beet plants on a number of occasions by the author. It was common during 1927, 1929, 1930 and 1931 in the Chatham-Wallaceburg district. The author's records have been published by Caesar and Ross (*9*) and Ross and Caesar (*34*).

The banded flea-beetle, *Systena taeniata* Say and the pale striped flea-beetle, *Systena blanda* Melsh., severely damaged sugar-beets in the vicinity of Wallaceburg in 1930. The report by the author is given in the Canadian Insect Pest Review for July, 1930. The latter species was also reported by Gibson (*15*) as injurious to garden beets, mangels and other crops in Middlesex county, in 1912.

Disonycha xanthomelas Dalm., according to Gibson (*15*), attacks spinach, beets and other plants in Ontario and Quebec. It was fairly abundant on sugar-beet plants in the vicinity of Chatham during 1932. The author's report was published by Caesar and Ross (*10*).

Blister beetles are reported as feeding upon beets in Ontario by Bethune (*2*) who states that *Epicauta cinerea* Forst., and *Epicauta pennsylvanica* DeG., are the most common species. Gibson (*22*) lists the same species as well as *Macrobasis unicolor* Kby., as attacking beets in eastern Canada. The same author (*20*) states that the latter species was abundant on young beets near Ottawa in 1915.

Wireworms (Elaterids) were reported by Noble (*28*) as damaging sugar-beets in Essex county during 1916. Ross and Caesar (*34*) published a report of the author to the effect that wireworms were particularly abundant in southern Ontario during 1931. Sugar-beets were among the crops damaged. Dustan (*13*) states that wireworms burrow into the fleshy roots of beets in the late summer.

The spinach or beet leaf miner, *Pegomyia hyoscyami* Panzer, attacks spinach, and in Ontario most of the records are for this host plant. Caesar (*4*) states that the insect was common on spinach at Guelph in 1911. Ross (*32*) noted it on garden beets in Bowmanville in 1913, while Caesar (*5*) again noted it on beets in 1916. Caesar and Ross (*8*) record the insect as prevalent and destructive to beets and mangels at Burlington and Guelph during 1918. The same authors (*33*) state that the insect severely attacked spinach, beets, mangels and lamb's quarters in many parts of the province during 1924. Hutchings (*25*) records damage to spinach and beets in many gardens in the Ottawa district during 1927. Caesar (*12*) states that in 1930 a very severe attack to spinach occurred in the Niagara district during May and June. In one case, twenty-five acres of crop were completely destroyed. Ross and Caesar (*34*) report that the insect was again destructive in the Niagara district during 1931. It practically ruined all spinach not harvested by June 2. General accounts of this insect in Ontario are given by Bethune (*2*), Gibson (*22*), Caesar (*7*), Gibson and Twinn (*24*), and Dustan (*13*).

The tarnished plant bug, *Lygus pratensis* L., was observed by Painter (*30*) laying eggs in the petioles of beet leaves. Caesar (*7*) states that beets are a favourite host plant of this insect.

Empoasca mali Le Baron is listed by Caesar (*7*) as feeding upon sugar-beets in Ontario.

Aphis gossypii Glover includes spinach, beets and other plants among its food plants in Ontario and Quebec, according to Dustan (*13*). *Aphis rumicis* L., is said by Dustan (*13*) to feed upon beets and other plants. *Myzus persicae* Sulz., is mentioned by Caesar (*7*) and Dustan (*13*) as feeding upon beets and spinach, but no definite records are given.

The sugar-beet nematode, *Heterodera schachtii* Schmidt, was reported in one field of sugar-beets near Glencoe during 1931. The infestation was described by Brown (*3*), Stirrett and Painter (*36*).

Slugs are mentioned by Caesar (*7*) as feeding upon beets in Ontario. No definite records are given.

INCIDENTAL NOTES ON SUGAR-BEET INSECTS IN ONTARIO

Some insects recorded by the author and published by others have been noted above. The following notes are designed to give a brief review of the insects that have been noticed on sugar-beets other than in the regular collections during the past few years.

Cutworms.—It is probable that several species are responsible for injury to sugar-beets in the region. Some damage is occasioned each year, but damage was particularly noticeable during 1931. During this year, adults of *Euxoa messoria* Harr., were reared from larvae severely damaging sugar-beets near Belle River.

Clover cutworm, *Scotogramma trifolii* Rott.—Larvae of this insect are fairly common in sugar-beet fields. They were noted particularly during 1933 and in 1934 they were the most common lepidopterous larvae on sugar-beet leaves. They were not abundant enough to cause damage except to individual plants.

Sod webworms, *Crambus zeellus* Fern., and *Crambus trisectus* Walk.—Larvae of these species were found attacking sugar-beets in a field near Wallaceburg during 1931. The injury was of minor importance.

Banded woolly bear, *Isia isabella* S. and A.—Larvae of this insect are sometimes found eating the leaves of sugar-beets.

Salt-marsh caterpillar, *Estigmene acrea* Drury.—Larvae of this insect were found eating sugar-beet leaves during 1932. They were not abundant, and hence no damage was done except to individual plants. Numerous larvae were killed during September by the fungus *Empusa grylli* (Fres.) Thaxter.

Yellow woolly bear, *Diacrisia virginica* Fab.—Larvae of this insect are fairly common in sugar-beet fields. They have not been abundant enough to cause damage except to isolated plants.

Black blister beetle, *Epicauta pennsylvanica* DeG.—Adults of this insect have been noted on sugar-beets during 1932 and 1934. They have not been abundant enough to cause widespread or notable damage, although they defoliated individual plants in a field.

Root aphid, *Pemphigus* sp.—H. D. Brown, of the Canada and Dominion Sugar Company, reported an infestation of root aphids on sugar-beets in a field near Haycroft on August 21, 1933. The insects were feeding in cracks in the beets and on secondary roots. A visit to the field early in September failed to reveal the aphids, and no injury could be found. Specimens were submitted to W. A. Ross of the Entomological laboratory, Vineland, but owing to their poor condition, determination could be made only to the genus.

Black aphid, *Aphis rumicis* group.—Aphids were found in small numbers on sugar-beet leaves at Chatham on July 14, 1933. They were not abundant enough to cause damage. W. A. Ross of the Entomological Laboratory, Vineland, made the determination.

Spinach or beet leaf miner, *Pegomyia hyoscyami* Panz.—As will be noticed below, adults of this important beet and spinach insect are very common in collections of insects from beet fields. The mines in the leaves, however, are not very common and these were not found in any numbers until 1934 when one field near Chatham had a considerable number of leaves showing mines early in June. Specimens of adults submitted to Howard Curran were identified as *Pegomyia* sp. There can be little doubt, however, that the insect is *Pegomyia hyoscyami* Panzer. Adults were reared from mines during 1934. This insect is a very important and destructive beet pest in Europe. It has occasioned serious damage to sugar-beets in California and to spinach in Ontario. In time, it may develop into a major pest in Ontario.

It is interesting to note that three notorious pests of sugar-beets occurring in other sugar-beet regions in North America are present in this region, namely, sugar-beet webworm, *Loxostege sticticalis* Linn., alfalfa webworm, *Loxostege commixtalis* Wlk., and common garden webworm, *Loxostege similalis* Gn. Larvae of these have not been found as yet on sugar-beets, although the adults are fairly common as judged from light trap catches.

REGULAR COLLECTIONS OF INSECTS FROM SUGAR-BEET FIELDS

During 1933 and again in 1934, more or less weekly collections of insects were made in a sugar-beet field near Chatham.

The following tables indicate the name, date and numbers of each insect collected during the season.

The collections were made by sweeping the beet foliage with an insect net. The collecting period was approximately twenty minutes in duration for each date.

From the Tables 1 and 2 it will be noted that collections were made during only part of each growing season.

There is a great variation in the number of species present in the two years and also in the numbers of any particular species from year to year. During 1933, about twice as many species were taken as during 1934, the reduction being largely in the fewer number of Coleoptera and Homoptera present during 1934.

Among the Coleoptera in 1933 there were nine species of flea-beetles, several of which are known to be destructive to sugar-beets, namely, *Disonycha xanthomelas* Dalm., *Epithrix cucumeris* Harr., *Systena frontalis*

TABLE 1.—SHOWING THE INSECTS AND THEIR NUMBERS COLLECTED FROM A SUGAR-BEET FIELD DURING THE SEASON 1933, CHATHAM, ONTARIO

Insect (Adults)	July 14	Aug. 4	Aug. 11	Aug. 24	Aug. 30	Sept. 13	Sept. 21
COLEOPTERA							
Baris scolopacea Germ.	3	8					
Chaetocnema denticulata Illig.		1					
Chaetocnema minuta Melsh.		2					
Chaetocnema pulicaria Melsh.		4	7	10			
Diabrotica 12-punctata Fab.	1	1	5		4	2	
Disonycha xanthomelas Dalm.	1	4	2		1	1	
Epicauta pennsylvanica DeG.			1	3			
Epithrix cucumeris Harr.	3	69	21	15	4		
Epithrix parvula Fab.					1		
Hypera punctata Fab.			1				
Longitarsus testaceous Melsh.		5	11	3	21		
Psylliodes punctulata Melsh.	8	54	17	6	6		2
Systena frontalis Fab.			1				
DIPTERA							
Euxesta notata Wied.	8	2					
Pegomyia sp.	18	63	11		3	2	6
HEMIPTERA							
Adelphocoris rapidus Say		13	8	6	4	1	
Chlamydatus associatus Uhl.		3	1		5		
Corimelaena pulicaria Germ.			1				
Lygus pratensis Linn.	190	471	142	45	21	41	16
Melanotrichus flavosparsus Sahlb.	7	92	2	9	11	8	1
Nabis ferus L.		2	3	1	1	1	
Nysius ericae Schill.	1					1	
Orius insidiosus Say			9	1	1		
Piesma cinerea Say		7	2				
Plagiognathus sp.					1		
Trigonotylus sp.		1					
HOMOPTERA							
Agallia sanguinolenta Prov.		4	2	5	2		
Ceresa bubalis Fab.				1			
Cicadula divisa Uhl.		6	7		1	5	
Cixius basalis VanD.		3				1	
Corythucha sp.			11				
Deltocephalus inimicus Say		5	2	6	5		
Empoasca fabae Harr.	557	566	156	31	20	2	
Eutettix seminudus Say		4	2	1			
Mesamia nigridorsum Ball	1						
Oliarus humilis Say						1	
Platymetopius acutus Say					2	1	
Platymetopius frontalis VanD.				1			
Schaphoideus immistus Say	2						
Stobaera tricarinata Say		1					

Fab., and *Psylliodes punctulata* Melsh. The latter species has been the most injurious in the Chatham district. In years when this insect is destructive, most of the damage is done in June. In 1934, some of the species listed did not occur in the fields under study, but another important and destructive flea-beetle, *Systena blanda* Melsh., was present.

The presence of *Baris scolopacea* Germ., in the field is interesting as this insect is a fairly recent introduction into the North American fauna.

TABLE 2.—SHOWING THE INSECTS AND THEIR NUMBERS COLLECTED FROM A SUGAR-BEET FIELD DURING THE SEASON 1934, CHATHAM, ONTARIO

Insect (Adults and Nymphs)	July 20	July 27	Aug. 3	Aug. 10	Aug. 18	Aug. 25	Sept. 3	Sept. 8 (Partial)
COLEOPTERA								Raining —too wet to collect
Diabrotica 12-punctata Fab.	1	3	1	9	6	6	13	
Disonycha xanthomelas Dalm.		3			1		3	2
Epicauta pennsylvanica DeG.				5	7	2	7	
Hypera punctata Fab.							1	
Psylliodes punctulata Melsh.	32	193	3	59	46	19	25	
Systena blanda Melsh.	4	8	1					
Systena frontalis Fab.					2	7	1	
DIPTERA								
Pegomyia sp.	1	135		131	53	25	56	5
HEMIPTERA								
Adelphocoris rapidus Say				1				
Chlamydatus associatus Uhl.							19	
Leptocoris trivittatus Say					1			
Lygus pratensis Linn.	78	221	15	30	41	34	50	1
Melanotrichus flavosparsus Sahlb.	390	208	13	36	40	5	29	
Nabis ferus L.					1			
Nysius ericae Schill.				19	25		20	
Trigonotylus sp.	3	3		1			2	
HOMOPTERA								
Agallia sanguinolenta Prov.						7	15	
Ceresa bubalis Fab.		1						
Cixius basalis VanD.	5	25		21	15		12	
Empoasca fabae Harr.				14	11		51	
Eutettix seminudus Say							2	
LEPIDOPTERA								
Larvae of *Scotogramma trifolii* Rott.				9	20	22	47	3

The larvae have damaged fodder beets in the Ukraine. It has not been reported on beets in America, but has been found breeding in the stems of pigweed and ragweed in Connecticut. The black blister beetle, *Epicauta pennsylvanica* DeG., is one of the most destructive of blister beetles, although it has not as yet been destructive to sugar-beets in Ontario. The presence of *Hypera punctata* Fab., in sugar-beet fields is probably incidental as this insect is a pest of clovers and has not been recorded as feeding on beets. *Diabrotica duodecimpunctata* Fab., is a common insect in the vicinity of Chatham, but its relation to sugar-beets is unknown. The larvae and adults feed on a variety of crops.

Only two species of Diptera have so far been identified from among the collections. *Euxesta notata* Wied., is a fly which, in the larval stage, feeds in decaying vegetable matter. It has been found in decaying sugar-beets in California. Nothing is known of its food habits under Ontario conditions. Although the determination of *Pegomyia* sp., by Howard Curran

is not specific, there is little doubt but that the species is *Pegomyia hyoscyami* Panz. (beet or spinach leaf miner). It has been discussed above.

Among the Hemiptera, *Adelphocoris rapidus* Say, *Chlamydatus associatus* Uhl., *Piesma cinerea* Say, and *Nysius ericae* Schill., are destructive plant-feeding bugs and have been reported as injurious to the beet plant in other sections of North America. No injury has been identified under our conditions. *Lygus pratensis* L., is also a destructive plant-feeding insect. It is probably the most abundant insect in our sugar-beet fields, but no damage has been identified. *Melanotrichus flavosparsus* Sahlb., is also a very common insect in the fields; little is known regarding its habits except that it occurs mainly on *Chenopodium*. *Nabis ferus* L., is a predacious bug. The economic status of *Orius insidiosus* Say, is uncertain, but it is probably predacious. *Corimelaena pulicaria* Germ., is a common insect breeding on pigweed, beggar's ticks and other plants. It has injured celery. Its status in regard to sugar-beets is unknown, but it is probably injurious.

Very little is known regarding many of the species of Homoptera except that they are all plant-feeding insects. *Agallia sanguinolenta* Prov., is a pest of clovers, and sugar-beets are often seriously damaged when planted after clover in Colorado. No injury has been identified in Ontario. *Cicadula divisa* Uhl., has been reported in sugar-beet fields in Illinois. It has caused a leaf burn on vegetable crops in Quebec. It has also been reported as concerned in the transmission of a number of plant diseases. Nothing is known regarding its activities in the sugar-beet fields of Ontario. *Empoasca fabae* Harr., was an extremely abundant insect in 1933. It has not been reported in beet fields before unless under the name of *Empoasca flavescens* Fab., from Illinois. No damage has been determined in Ontario.

COLLECTIONS FROM VARIOUS FIELDS IN CHATHAM DISTRICT

During 1933 and 1934, collections were made from various sugar-beet fields throughout the district. In 1933 they were made in thirteen fields, while in 1934 they were made from twenty-five fields. It must be noted that only one collection was made from each field and that all collections were not made at the same time. The results indicate to some extent the distribution of the various insects in the sugar-beet fields of the district.

From Table 3 it can be seen that the following were the most widely distributed insects occurring in the fields studied during the two years: *Lygus pratensis* L., *Melanotrichus flavosparsus* Sahlb., *Empoasca fabae* Harr., *Pegomyia* sp., *Psylliodes punctulata* Melsh., and *Cixius basalis* VanD. Others occurring commonly were *Chaetocnema pulicaria* Melsh., *Diabrotica 12-punctata* Fab., *Systena blanda* Melsh., *Chlamydatus associatus* Uhl., *Nysius ericae* Schill., *Trigonotylus* sp., *Nabis ferus* L., *Agallia sanguinolenta* Prov., *Cicadula divisa* Uhl., and the larvae of *Scotogramma trifolii* Rott.

TABLE 3.—SUMMARY OF COLLECTIONS OF INSECTS FROM SUGAR-BEET FIELDS IN CHATHAM DISTRICT DURING 1933 AND 1934

Insect	Number of fields in which insect was found		Insect	Number of fields in which insect was found	
	1933 Total 13 fields	1934 Total 25 fields		1933 Total 13 fields	1934 Total 25 fields
COLEOPTERA			HEMIPTERA		
Baris scolopacea Germ.	1	0	*Nabis ferus* L.	6	1
Chaetocnema denticulata Illig.	1	0	*Nysius ericae* Schill.	1	10
Chaetocnema minuta Melsh.	2	0	*Orius insidiosus* Say	1	0
Chaetocnema pulicaria Melsh.	5	0	*Piesma cinerea* Say	1	0
Diabrotica 12-punctata Melsh.	2	13	*Plagiognathus* sp.	1	0
Dibolia borealis Chev.	1	0	*Trigonotylus* sp.	2	11
Disonycha triangularis Say	1	0			
Disonycha xanthomelas Dalm.	2	2	HOMOPTERA		
Epicauta pennsylvanica DeG.	1	1			
Epithrix cucumeris Harr.	4	0	*Agallia sanguinolenta* Prov.	5	2
Epithrix parvula Fab.	1	0	*Ceresa bubalis* Fab.	1	0
Glyptina brunnea Horn	1	0	*Cicadula divisa* Uhl.	5	0
Hypera punctata Fab.	1	0	*Cixius basalis* VanD.	4	16
Longitarsus testaceous Melsh.	1	0	*Corythucha* sp.	1	0
Ochrosis atriventris Melsh.	1	0	*Deltocephalus inimicus* Say	3	0
Psylliodes punctulata Melsh.	6	21	*Empoasca fabae* Harr.	8	19
Systena blanda Melsh.	3	8	*Eutettix seminudus* Say	1	0
Systena frontalis Fab.	1	4	*Mesamia nigridorsum* Ball	1	0
			Oliarus humilis Say	3	1
DIPTERA			*Phlepsius irroratus* Say	2	0
			Platymetopius acutus Say	2	0
Euxesta notata Wied.	1	0	*Platymetopius frontalis* VanD.	1	0
Pegomyia sp.	8	20	*Schaphoideus immistus* Say	1	0
			Stobaera tricarinata Say	2	0
HEMIPTERA					
			LEPIDOPTERA		
Adelphocoris rapidus Say	4	2	Larvae of		
Chlamydatus associatus Uhl.	5	2	*Scotogramma trifolii* Rott.	0	9
Corimelaena pulicaria Germ.	1	0			
Leptocoris trivittatus Say	0	3	ORTHOPTERA		
Lygus pratensis L.	13	24			
Melanotrichus flavosparsus Sahlb.	11	23	*Dissosteria carolina* L.	0	1
			Melanoplus femur-rubrum femur-rubrum DeG.	0	1

THE BENEFICIAL INSECTS OF SUGAR-BEET FIELDS

It is not intended to discuss all of the beneficial insects found in beet fields as many of these are as yet unknown to us. In our collections, however, certain well-known beneficial insects have been taken and these are indicated as follows: Among the Coccinellidae, adults of *Coccinella novemnotata* Hbst., *Coccinella perplexa* Muls., *Hippodamia parenthesis* Say, *Hippodamia convergens* Guer., *Hippodamia trifida* Say, *Hippodamia 13-punctata* L., and *Ceratomegilla fuscilabris* Muls., are all common in sugar-beet fields.

The cicindelid, *Cicindela punctata* Oliv., is fairly common, but its habits are unknown except that it is supposed to be predacious.

Among the Diptera, many tachinid flies are present, but none have been identified as yet. Adults of the fly *Chloropisca glabra* Mg., are very

abundant in nearly all sugar-beet fields. Larvae of this fly are known to be predacious on root-feeding aphids in Montana (*31*) and in France (*27*). Its hosts in our fields have not been determined.

The hemipterous bug *Nabis ferus* L., is a predacious species, commonly found in sugar-beet fields in Ontario.

AN ANNOTATED CATALOGUE OF THE INVERTEBRATES ASSOCIATED WITH THE BEET PLANT IN ONTARIO

PHYLUM ARTHROPODA

Class Insecta

Order Coleoptera

Family Chrysomelidae

Chaetocnema denticulata Illig.—This insect was found sparingly in sugar-beet fields in the vicinity of Chatham. It has also been reported as injurious to sugar-beets in Illinois and Nebraska.

Chaetocnema minuta Melsh.—This insect was found sparingly in sugar-beet fields near Chatham.

Chaetocnema pulicaria Melsh. (Corn flea-beetle).—A common insect in sugar-beet fields in certain years in the Chatham district. It has been found on sugar-beets in Illinois.

Diabrotica 12-punctata Fab. (Spotted cucumber beetle).—This insect is common in sugar-beet fields in the vicinity of Chatham; also recorded from sugar-beet fields in Illinois, Nebraska and Oregon.

Dibolia borealis Chev.—This insect is found sparingly in sugar-beet fields in the vicinity of Chatham. The larvae live in the leaves of plantain.

Disonycha triangularis Say.—A common flea-beetle in sugar-beet fields in the Chatham district. It has been reported as injurious to sugar-beets in Ohio, Iowa and Colorado, and to seedling beets in southern Manitoba and southern Saskatchewan.

Disonycha xanthomelas Dalm. (Spinach flea-beetle)—A common flea-beetle in sugar-beet fields in the vicinity of Chatham. Adults and larvae were conspicuous during 1932. It has also been reported feeding on beets in other sections of Ontario. It is a common beet insect in Illinois and has been reported on beets in Connecticut and Ohio.

Epithrix cucumeris Harr. (Potato flea-beetle)—A common flea-beetle in sugar-beet fields near Chatham. It is reported as destructive to sugar-beets in Illinois, Nebraska and Utah.

Epithrix parvula Fab. (Tobacco flea-beetle)—This insect is unimportant and scarce in sugar-beet fields in the vicinity of Chatham.

Glyptina brunnea Horn—This insect is scarce in sugar-beet fields in the Chatham district; also reported on sugar-beets in Illinois.

Longitarsus testaceous Melsh.—A fairly common flea-beetle, but found only in one field of sugar-beets in the Chatham district.

Ochrosis atriventris Melsh.—This insect is scarce in sugar-beet fields in the vicinity of Chatham; also reported from sugar-beet fields in Illinois.

Psylliodes punctulata Melsh. (Hop flea-beetle)—A common and destructive insect on sugar-beets in the vicinity of Chatham. It damages the beets

just after they are through the soil. It has been reported as injurious to sugar-beets in Alberta, beets in British Columbia and Quebec in Canada and in Ohio, Washington and Utah in the United States.

Systena blanda Melsh. (Pale striped flea-beetle)—This species and *Systena taeniata* Say are periodically destructive to early sugar-beets in the Chatham district. It has also been reported as destructive to beets and mangels in Middlesex county. The two species have been confused in literature. Many host plants.

Systena frontalis Fab. (Red-headed flea-beetle)—A fairly common insect in the vicinity of Chatham; also reported as injurious to sugar-beets in New York and Illinois.

Systena taeniata Say (Banded flea-beetle)—This species and *Systena blanda* Melsh., periodically damage sugar-beets just after they are through the soil in the Chatham district. Reported as injurious to beets in New York, Illinois, Colorado and Utah.

Family Curculionidae

Baris scolopacea Germ.—This insect is scarce, but found in one field in the vicinity of Chatham. The larvae are reported destructive to fodder beets in the Ukraine. In the United States the insect has been found breeding in stems of pigweed and ragweed in Connecticut.

Hypera punctata Fab. (Clover leaf weevil)—This insect is scarce in the Chatham district, being found in one field. It is a well-known clover pest and its collection in sugar-beet fields is probably incidental.

Family Elateridae

Wireworms (*Limonius* sp. and others)—Wireworms are common pests of sugar-beets in the Chatham district. These well-known insects also attack sugar-beets in many other sections of North America.

Family Meloidae

Epicauta cinerea Forst.—One of the common species in Ontario which has been reported as feeding on beets.

Epicauta pennsylvanica DeG. (Black blister beetle)—So far this insect has been scarce in the Chatham district. It occurs generally throughout Ontario. It is the most destructive of the blister beetles and has damaged sugar-beets in New York, Michigan, Minnesota, Iowa and Nebraska.

Macrobasis unicolor Kby. (Ash-gray blister beetle)—Occurs in the region of Chatham, but not taken on beets. Reported on garden beets near Ottawa. It has damaged sugar-beets in Iowa, Nebraska and Colorado.

Family Scarabeidae

Phyllophaga spp. (White grubs)—Sometimes abundant enough to cause damage to sugar-beets in the vicinity of Chatham. Widespread pests with many host plants.

Order Diptera

Family Muscidae

Pegomyia hyoscyami Panz. (Beet or spinach leaf miner)—A common insect but has not caused damage to sugar-beets in Ontario so far as known. Destructive to spinach throughout Ontario. A major pest of sugar-beets in Europe.

Family Otitidae

Euxesta notata Wied. (Spotted root-fly)—This insect is common in sugar-beet fields near Chatham. Larval food undetermined, but has been found in decaying beets in California.

Order Hemiptera

Family Anthocoridae

Orius insidiosus Say—This insect is scarce in the vicinity of Chatham. It is common in beet fields in many parts of the United States. Economic status uncertain.

Family Corimelaenidae

Corimelaena pulicaria Germ.—This insect is scarce in the Chatham district. Occasionally found on sugar-beets in Illinois.

Family Corizidae

Leptocoris trivittatus Say (Box elder bug)—This insect is scarce in the Chatham district. Its presence in sugar-beet fields probably incidental.

Family Lygaeidae

Nysius ericae Schill. (False chinch bug)—This insect is common on sugar-beets in the vicinity of Chatham. It is reported as injurious to sugar-beets in Illinois, Iowa, Nebraska, Colorado, Utah and other states. It seems to be increasing in destructiveness as a sugar-beet pest.

Family Miridae

Adelphocoris rapidus Say (Dusky leaf bug)—This insect is common on sugar-beets in the Chatham district. It is reported as being common in sugar-beet fields in Illinois and has caused considerable injury to sugar-beets at times in Minnesota.

Chlamydatus associatus Uhl. (False flea-hopper)—This insect is common on sugar-beets in the Chatham district. It is a common insect in sugar-beet fields in New York, Ohio, Illinois, Colorado and Utah. It attacks sugar-beets in midsummer, but with little damage.

Lygus pratensis Linn. (Tarnished plant bug)—Very common, although no injury has been noted near Chatham. It is very common also in sugar-beet fields in Illinois, Iowa, and other states, and in Russia.

Melanotrichus flavosparsus Sahlb. A very common insect in sugar-beet fields near Chatham. No injury caused by this insect has been identified.

Plagiognathus sp.—This insect is scarce in sugar-beet fields in the vicinity of Chatham.

Trigonotylus sp.—This insect is scarce in sugar-beet fields in the vicinity of Chatham.

Family Nabidae

Nabis ferus L.—A fairly common insect in sugar-beet fields in the Chatham district. This is a predacious bug.

Family Piesmidae

Piesma cinerea Say (Pigweed bug)—This insect is scarce in the Chatham district. It has damaged sugar-beets in Illinois, Iowa and Nebraska.

Order Homoptera

Family Aphiidae

Aphis gossypii Glover—This species has been reported upon beets and spinach in Ontario. No definite localities.

Aphis rumicis group (Black beet aphid)—Aphids of this group have been taken on sugar-beets at Chatham. *Aphis rumicis* L., is a common and widespread species. It has injured seed beets in Connecticut. It is a'so a very injurious sugar-beet insect in France, England, Poland, Denmark, Italy and Czechoslovakia.

Myzus persicae Sulz.—This species has been mentioned as feeding upon beets and spinach in Ontario.

Pemphigus sp. (Root aphid)—This species has been taken on beet roots near Chatham.

Family Cicadellidae

Agallia sanguinolenta Prov.—A common sugar-beet insect in the vicinity of Chatham. It has been found on sugar-beets in Illinois, Iowa and Nebraska. This crop following clover is often damaged in Colorado.

Cicadula divisa Uhl. (*sexnotata* Amer. auct. nec. Fall)—Fairly common on sugar-beets in the Chatham district. It is reported as common in Illinois sugar-beet fields. It has caused leaf-burn on vegetable crops, and is concerned in the transmission of yellow dwarf of onions, and aster yellows.

Deltocephalus inimicus Say—Fairly common in sugar-beet fields near Chatham. It is especially common in sugar-beet fields in Illinois. It is more a pest of grasslands and cereal crops.

Empoasca fabae Harr. (Potato leafhopper)—This insect is very common in sugar-beet fields in the vicinity of Chatham. No injury has been identified.

Empoasca mali Le Baron—This species has been mentioned as feeding upon sugar-beets in Ontario.

Eutettix seminudus Say—This insect is very scarce in sugar-beet fields in the Chatham district. It is also reported from sugar-beets in Illinois.

Mesamia nigridorsum Ball—This insect is very scarce in sugar-beet fields near Chatham.

Phlepsius irroratus Say—This insect is scarce in sugar-beet fields near Chatham. It has been taken on sugar-beets in Illinois. It causes a dark purple spotting of the leaves. It is found also on lamb's quarters, alfalfa and clover.

Platymetopius acutus Say—This insect is scarce in sugar-beet fields near Chatham. It is reported from sugar-beet fields in Illinois and Colorado.

Platymetopius frontalis VanD.—Scarce in sugar-beet fields near Chatham.

Schaphoideus immistus Say—This insect is very scarce in sugar-beet fields near Chatham.

Family Fulgoridae

Cixius basalis VanD.—Fairly common in sugar-beet fields near Chatham.

Oliarus humilis Say—Fairly common in sugar-beet fields near Chatham.

Stobaera tricarinata Say—Fairly common in sugar-beet fields in the Chatham district. It is also reported from sugar-beet fields in Illinois and Nebraska.

Family Membracidae

Ceresa bubalis Fab. (Buffalo tree hopper)—This insect is scarce in sugar-beet fields near Chatham.

Family Tingidae

Corythucha sp.—This insect is very scarce in sugar-beet fields near Chatham.

Order Lepidoptera

Family Arctiidae

Diacrisia virginica Fab. (Yellow woolly bear)—This insect is common in sugar-beet fields in the vicinity of Chatham, although no widespread damage has been noted. It is a widespread species and is sometimes quite injurious to sugar-beets.

Estigmene acraea Dru. (Salt marsh caterpillar)—The larvae of this insect are fairly common in sugar-beet fields in the Chatham district. It is a common and widespread species and has seriously infested sugar-beets in California.

Isia isabella S. and A. (Banded woolly bear)—This insect is fairly common in sugar-beet fields in the vicinity of Chatham. It is a widespread species with many host plants. It has injured sugar-beets in Illinois.

Family Noctuidae

Autographa brassicae Riley—This insect has been reported on beets in Ontario.

Ceramica picta Harr. (Zebra caterpillar)—Reported as feeding on mangels and sugar-beets in Ontario. Not noticed on this crop to date at Chatham. It has damaged sugar-beets in Michigan, Illinois, Colorado, California and Idaho.

Cirphis unipuncta Haw. (Armyworm)—An outbreak of this insect occurred in the sugar-beet growing district of Ontario in 1914. Many types of crops were damaged, but sugar-beets and mangels were fairly free from attack. It has also been observed on beets in Colorado.

Euxoa messoria Harr. (Dark-sided cutworm)—This insect is the most common cutworm in the sugar-beet growing district of Ontario. Adults have been reared from larvae attacking sugar-beets. It has also been recorded on sugar-beets in the state of Washington.

Euxoa ochrogaster Gn. (Red-backed cutworm)—This insect has damaged garden beets in the vicinity of Ottawa, Ontario. It has also damaged sugar-beets in southern Saskatchewan and Alberta.

Euxoa tessellata Harr. (Striped cutworm)—This insect has been reported on beets near Ottawa, Ontario.

Graphiphora c-nigrum L.—This insect destroyed a field of mangels near Ancaster, Ontario, in 1914.

Peridroma margaritosa Haw.—This insect has been reported feeding upon beets in Ontario.

Scotogramma trifolii Rott. (Clover cutworm or striped beet caterpillar)—This insect is common on sugar-beets in the vicinity of Chatham, although no damage to the plants has been noted. It damaged mangels

near Paris, Ontario, in 1888. It has injured sugar-beets in Illinois, Nebraska, and other states and is a minor pest of sugar-beets in Czechoslovakia.

Septis arctica Bdv.—This species is stated to attack spinach and other vegetables in Ontario.

Family Pyralididae

Crambus trisectus Wlk. (Larger sod webworm)—Larvae of this insect were found in sugar-beet roots near Chatham on one occasion. The damage was unimportant.

Crambus zeellus Fern. (Corn root webworm)—Larvae of this insect were found in sugar-beet roots near Chatham on one occasion. The damage was unimportant.

Phlyctaenia rubigalis Gn. (Greenhouse leaf-tyer)—This insect has been reported on sugar-beets in Ontario. It is a very common insect in the vicinity of Chatham, but has not as yet been noted on sugar-beets.

Pyrausta nubilalis Hbn. (European corn borer)—This insect has attacked sugar-beets in the vicinity of Chatham when these were near corn fields. The sugar-beet plant acts as a shelter plant except in rare cases when eggs are laid on this plant. It has also been reported in sugar-beets in Ohio. In Massachusetts and other eastern states it is a primary pest of beets. It has also damaged sugar-beets in Japan and Russia.

Order Orthoptera

Family Acrididae

Dissosteria carolina Linn. (Carolina grasshopper)—A common species in the vicinity of Chatham, but no damage to sugar-beets has been noted, although individual insects have been taken in the fields. It has also been found in sugar-beet fields in Michigan, Nebraska, Colorado, Washington and California.

Melanoplus femur-rubrum femur-rubrum DeG. (Red-legged grasshopper)—A common species in the vicinity of Chatham which has been found in sugar-beet fields. No damage was noted. It has also been observed in sugar-beet fields in Michigan, Illinois, Colorado, Oregon and California.

PHYLUM MOLLUSCA

Slugs—Slugs have been mentioned as feeding upon beets in Ontario. No definite records are given.

PHYLUM NEMATODA

Heterodera schachtii Schmidt (Sugar-beet nematode)—This nematode was found in one field of sugar-beets near Glencoe in 1931. The field was treated and has not grown sugar-beets since. No other infestations have been found in Ontario. It is a serious pest of sugar-beets in Europe, and in sections of the sugar-beet growing areas of Nebraska, Colorado, Utah, Idaho and California.

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ON THE PRODUCTION OF SCLEROTIA BY RHIZOCTONIA SOLANI KÜHN. IN PURE CULTURE[1]

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INTRODUCTION

Although there has been much investigation with respect to the vegetative growth of *Rhizoctonia Solani*, perhaps insufficient attention has been given to the formation of its sclerotia and the rôle which they play in the production of disease. Since these bodies provide potential foci for the continuance and dissemination of the organism it is necessary to ascertain the extent to which various factors of the chemical and physical environment might affect their production.

Certain results have been obtained by others with respect to the effect of mineral nutrition and other factors on vegetative growth, and, in certain cases, their effect on sclerotia. Müller (*9*), using various combinations of carbonaceous and nitrogenous food, concluded that potassium nitrate, supplied at a concentration of 0.5%, was, for the mycelial growth, a more suitable nitrogen source than 0.5% ammonium sulphate or ammonium nitrate, when the supplementary calcium source was held constant. The amino acids, alanine, leucine and tyrosine were also excellent vehicles of nitrogen supply, and the simple 5- and 6-carbon atom sugars were consistently more suitable for the organism than the higher sugars or other complex carbohydrates. Finlow (*5*), in studying the pathogenicity of *R. Solani* on jute, observed that a positive correlation may exist between severe infection by *R. Solani* and a deficiency of potassium in the soil. However, he did not refer to sclerotia in this connection. Matsumoto (*6*) found that sclerotia formation was checked when the concentration of glucose in the substrate was increased from 0.37 to 0.75 molar. Young and Bennett (*13*) concluded that *R. Solani* did not grow upon Richard's solution when calcium was absent. Braun (*2*), in studying the influence of nutritive elements, concluded that the development of sclerotia was not necessarily augmented by increasing the available food, but rather by the addition of some particular substance, such as lactic acid.

In the present work an effort was made to determine the effects on sclerotia formation of the important elements, phosphorus, potassium, nitrogen, magnesium, calcium and sulphur, and also of other environmental factors, including the reaction of substrate, temperature, humidity, aeration and of irradiation.

MATERIAL AND METHODS

The formation of sclerotia was studied in the laboratory, using agar media, in Petri plates, and aqueous media in 200 cc. Erlenmeyer flasks. More than 3,000 plates, and over 400 flasks were employed during the experiment. In plate culture the sclerotial growth was estimated on a

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percentage basis according to the area of the plate covered and the size of the bodies. The vegetative growth of the fungus upon aqueous media was determined by weighing the mycelial mats, and estimating the sclerotia.

A stock nutrient solution was compounded for general use from C.P. chemicals as follows: 40 cc. molar $Ca(NO_3)_24H_2O$; 40 cc. half molar K_2SO_4; 16 cc. molar $MgSO_47H_2O$; 400 cc. hundredth molar $CaH_4(PO_4)_2$-H_2O; 1 cc. 0.5% iron sulphate solution; 15 gm. dextrose; and distilled water to 1000 cc. (25 gm. agar agar). This solution was useful in studying the nutritive value of nitrogen, potassium, magnesium and phosphorus, in that the quantity of any one of these elements could be varied in the media at will without influencing the concentration of the others. Moreover, as a general synthetic medium it favoured a fairly vigorous production of sclerotia.

The culture of *R. Solani* used was from a monosporous isolation originating from the *Corticium* stage on potato stalks. It produced sclerotia freely during the course of the investigation. For inoculation the amount of the fungus was kept constant throughout by employing a small cork borer to cut cylindrical plugs from the nutrient agar on which the fungus grew in the plates. More than 150 uniform plugs could be secured from a single plate, the age and condition of which were always comparable.

A good growth of the fungus on the aqueous nutrient substrate was secured by applying the inoculum to a floating disc of chemically treated cork.

With regard to the minerals indicated, each was used in various concentrations in both agar and aqueous media in which the amounts of the other elements were kept constant. The concentrations of the varied nutrients are given in Tables 1 and 2.

MINERAL NUTRITION

Phosphorus.—Preliminary tests indicated that sclerotia formation was associated very closely with the concentrations of phosphorus in the substrate. By narrowing the range of concentration of monobasic calcium phosphate, 31 p.p.m. and 7.5 p.p.m. appeared to be the optimal and minimal requirements, respectively. The type of sclerotial growth changed with the degree of mycelial development, there being considerable variation in the size and colour of sclerotia, and in the distribution and aggregation throughout the various treatments (Table 1). Both mycelial and sclerotial growth-results indicated a marked sensitivity of the organism to the available phosphorus in the medium (Plate 1).

The dry weights of the mats of mycelium and sclerotia formed on the surface of the aqueous substrate also indicated a similar relation in vigour of growth to the phosphorus content (Table 2). At phosphorus concentrations of 6 p.p.m., or less, no sclerotia formed and the mycelial development was greatly inhibited. No determinations were made in connection with the possible loss of available phosphorus by the formation of iron and magnesium compounds.

Nitrogen.—The results from these experiments (Table 2) show that nitrogen is absolutely necessary for the production of sclerotia. The minimum amount of nitrate nitrogen necessary was between 50 and 56

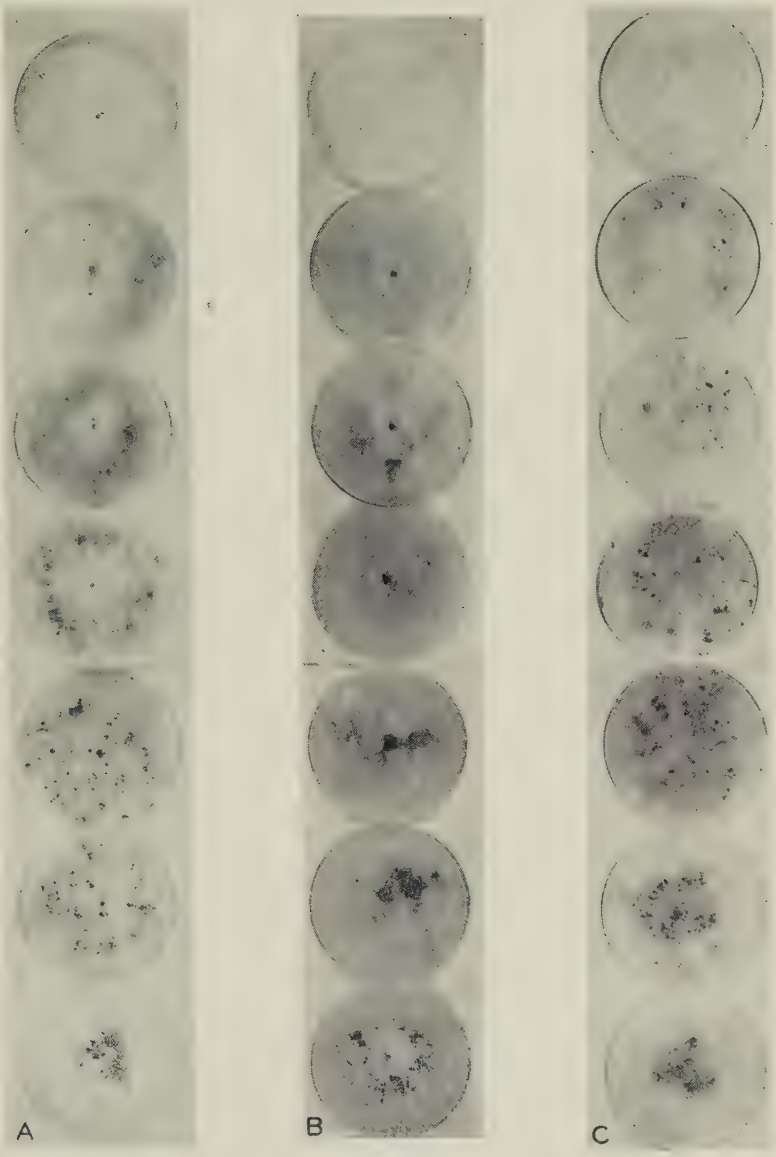

PLATE I

PLATE 1. Sclerotia formation by *Rhizoctonia Solani* in plate culture under varied concentrations of mineral nutrients. A. Top to bottom—0, 6, 7.5, 15, 31, 46, 248 p.p.m. phosphorus. B. Top to bottom—0, 49, 56, 83, 112, 140, 280 p.p.m. nitrate nitrogen. C. Top to bottom—0, 2, 4, 6, 8, 37, 391 p.p.m. potassium.

p.p.m. (Plate 1). The optimum concentration was approximately 560 p.p.m. Here again, as may be noted in Table 1, a close relationship exists between degree and type of growth of sclerotia. This sensitivity of the organism to the amount of nitrogen supplied is further apparent in Table 2, since, with a complete lack of nitrogen, mycelial growth was less than it was when any other element was omitted. The results of an experiment designed to determine the effects on sclerotia production when nitrogen is supplied in different ionic forms are not included in the tabulated data, but it may be of interest to state that while the degree of sclerotia formation differed somewhat under like concentrations of nitrogen supplied as NO_3, NH_3 and NO_2 ions, the type of sclerotia formed was very different. The minimal requirements of the different forms seemed to be almost alike, except in the case of NH_3 ions, where it was slightly lower. Moreover, in the latter case the sclerotia were pin-point in size and quantitative comparisons were difficult to make.

Large aggregated sclerotia formed on the media containing nitrogen in the nitrate and nitrite forms. Further, nitrogen in the nitrite form exerted some inhibitory effects on the mycelial growth of the organism at molecular concentrations which were suitable when the nitrate form was used. The observed superiority of the nitrate form of nitrogen as a food for *R. Solani* agrees with the results of Müller (*9*).

Potassium.—Potassium sulphate was used for studying the effects of potassium. Sclerotia were produced in abundance when a very small quantity of the element was present (Table 2). In fact it was impossible to determine the minimal point for sclerotial formation if unpurified agar was used, because enough potassium was present to promote their growth. However, by using purified "Bacto Agar" the minimal potassium concentration for sclerotia production was found. This occurred at about 2 p.p.m. (Plate 1). An optimum point was not observed with certainty, as sclerotia were produced almost equally well over a wide range of potassium concentrations. In the aqueous media a noticeable decrease in vigour of growth occurred at concentrations below 78 p.p.m. However, there was substantial mycelial growth when potassium was absent.

Magnesium.—Magnesium was supplied in the sulphate form. From an inspection of the data in Table 1, treatments 39–46, it is apparent that sclerotia production on agar substrata was somewhat curtailed at concentrations of Mg. below 20 p.p.m. In Table 2 it is seen that the total dry weight of the fungus, grown upon aqueous media containing no magnesium, was considerably less than when magnesium was present.

It has been concluded that the element does not definitely delimit the production of sclerotia, but small amounts are necessary for the optimum growth of both sclerotia and mycelium.

Calcium.—In determining the effect of calcium upon the development of sclerotia it was necessary to modify the complete nutrient formula used in a study of other elements, in order that calcium compounds might be excluded. Twenty cc. molar KNO_3 solution per litre replaced the Ca $(NO_3)_2 4H_2O$ as a nitrogen source, and 3 cc. molar KH_2PO_4 solution replaced the $CaH_4(PO_4)_2H_2O$ and K_2SO_4 as sources of phosphorus and potassium. This modified formula did not supply a nutrient medium so favourable for

TABLE 1.—DEVELOPMENT OF SCLEROTIA BY *Rhizoctonia Solani* IN PETRI PLATES AT 21°–25° C. DURING 17 DAYS, WHEN THE IONIC CONCENTRATIONS OF THE NUTRITIVE ELEMENTS P, K, N AND MG. WERE VARIED SINGLY IN A SYNTHETIC MEDIUM.

No.	Conc'n. p.p.m.*	Plates	Sclerotia		
			Index %	Size	Remarks
	(P)				
1	248	20	31	++	Large aggregates.
2	124	19	34	++	Large aggregates.
3	62	19	36	+++	Large aggregates—well distributed.
4	46	17	45	+++	Large aggregates—well distributed.
5	31	17	55	++++	Large aggregates—well distributed.
6	15	17	43	++	Produced on radians—absent at centre.
7	13.6	17	41	++	Produced on radians—absent at centre.
8	12.4	12	36	++	Produced on radians—absent at centre.
9	11.1	10	34	++	Produced on radians—absent at centre.
10	9.9	26	30	++	Produced in a narrow ring.
11	8.7	26	21	++	Produced in a narrow ring.
12	7.5	27	8	+	Produced in a narrow ring.
13	6.2	32	0	0	Mycelial mat thin.
14	5	15	0	0	Mycelial mat thin.
15	0	18	0	0	Mycelial mat thin.
	(K)				
16	1564	31	36	++++	Large aggregates at centre.
17	782	31	36	++++	Large aggregates at centre.
18	391	27	45	++++	Large aggregates at centre.
19	78	28	43	+++	Large aggregates at centre.
20	39	16	30	++	Small scattered sclerotia.
21	7.8	12	26	++	Small scattered sclerotia.
22	5.9	12	18	++	Small scattered sclerotia.
23	3.7	12	13	+	Small scattered sclerotia.
24	1.8	12	11	+	Small scattered sclerotia.
25	0	12	1	0	
	(N)				
26	1120	38	51	++++	Large sclerotia produced radially.
27	560	38	52	++++	Large sclerotia produced radially.
28	280	36	50	++++	Large sclerotia produced radially.
29	140	15	40	++++	Large sclerotia produced radially.
30	112	15	33	+++	Small sclerotia at centre.
31	84	15	17	+++	Small sclerotia at centre.
32	56	52	4	+	Mycelial mat thin.
33	50.4	12	0	0	Mycelial mat thin.
34	44.8	12	0	0	Mycelial mat thin.
35	39.2	12	0	0	Mycelial mat thin
36	33.6	12	0	0	Mycelial mat thin
37	28	12	0	0	Mycelial mat thin.
38	0	12	0	0	Mycelial mat thin.
	(Mg)				
39	389	22	38	+++	Sclerotia over whole surface.
40	195	22	28	+++	Sclerotia over whole surface.
41	49	22	30	++	Sclerotia over whole surface.
42	20	12	23	+	Sclerotia over whole surface
43	10	12	15	+	Sclerotia over whole surface.
44	5	12	13	+	Sclerotia over whole surface.
45	2.5	12	13	+	Sclerotia over whole surface.
46	0	12	12	+	Sclerotia over whole surface.

*P—Phosphorus added as $Ca\,H_4(PO_4)_2H_2O$.
K—Potassium added as K_2SO_4.
N—Nitrogen added as $Ca\,(NO_3)_24H_2O$.
Mg.—Magnesium added as $MgSO_47H_2O$.

TABLE 2.—GROWTH OF *Rhizoctonia Solani* IN 100 C.C. AQUEOUS MEDIA IN FLASKS INCUBATED AT 21°–25° C. FOR 30 DAYS, WITH THE IONIC CONCENTRATIONS OF THE NUTRITIVE ELEMENTS P, K, N AND MG. VARIED SINGLY.

Treatment No.	Concentration varied nutrient p.p.m.*	Dry weight fungous mat mgm.†	pH of media	
			Initial	Final
	(P)			
1	248	587	3.68	5.07
2	124	821	3.75	5.07
3	62	892	3.8	5.1
4	46	866	3.92	5.25
5	31	872	3.92	5.3
6	15	849	3.9	5.55
13	6	480‡	4.1	5.77
15	0	105‡	4.1	5.77
	(K)			
16	1564	658	3.75	6.13
17	782	643	3.75	6.13
18	391	551	3.78	5.95
19	78	530	3.92	5.73
20	39	539	3.88	5.78
20A	19	511	3.9	5.6
25	0	141‡	4.11	5.56
	(N)			
26	1120	584	3.65	5.63
27	560	828	3.88	5.93
28	280	852	3.92	6.07
32	56	433‡	4.06	6.1
37	28	266‡	4.06	5.73
37A	14	127‡	4.08	5.5
38	0	41‡	4.1	4.45
	(Mg)			
39	389	592	3.65	5.18
40	195	550	3.67	5.39
40A	98	694	3.68	5.63
41	49	655	3.7	5.6
41A	24	635	3.74	5.6
46	0	406	3.75	5.4

*P—Phosphorus added as $CaH_4(PO_4)_2H_2O$.
K—Potassium added as K_2SO_4.
N—Nitrogen added as $Ca(NO_3)_24H_2O$.
Mg.—Magnesium added as $MgSO_47H_2O$.
†Average for four flasks.
‡Indicates that no sclerotia were produced on the surface of the nutrient.

the growth of *R. Solani* as did the complete one. The data for calcium nutrition are not included in the tables.

It was found that the omission of calcium from the medium did not curtail sclerotia production nor the growth of mycelium. Likewise, increasing amounts of the element did not augment the development of sclerotia in any way. It has been concluded that calcium is not necessary for the growth of the strain of *R. Solani* used nor for the development of sclerotia.

Although Young and Bennett (*13*) found that sclerotia were not produced in a calcium-free medium, it is possible that the use of a strain of *R. Solani* differing in its reaction to calcium may explain the discrepancy in results.

Sulphur.—Amorphous sulphur dissolved in carbon bisulphide was added to complete nutrient agar in concentrations of 0, 64, 128, 320, 640, 1280, 1920 and 3200 p.p.m. sulphur. Six Petri plates were inoculated with *R. Solani* for each treatment.

The element proved toxic to the organism and inhibited both sclerotia production and mycelium growth to a degree corresponding to the concentration of sulphur in the medium.

A concentration of 320 p.p.m. completely suppressed the growth of sclerotia and supported only half the normal growth of mycelium. Higher concentrations effected further reduction in the degree of mycelial growth, many plates failing to show any growth whatever.

OTHER ENVIRONMENTAL FACTORS

Reaction of Substrate.—In order to determine whether the observed differences in the production of sclerotia in the foregoing treatments were due to changes in the reaction of the substrate, *R. Solani* was incubated in a complete nutrient medium, adjusted to a wide range of pH values. It was found that the sclerotia were produced readily between pH values of 3 and 9, with an optimum centering around pH 5.5. The growth of the fungus was completely inhibited at pH 2.5, but was quite vigorous at pH 3.5. These limitations agree with those of Matsumoto (*6*), who demonstrated that his strain of *R. Solani* grew readily between pH 3.0 and 9.5.

Since all pH values of any nutrient medium used were well above minimum for growth and sclerotia production, it is obvious that the reaction of the substrate within the range indicated could not be the limiting factor in determining the degree of sclerotia production when the increments of the nutrient added were very narrow. On the other hand, it is possible that when the increments are quite wide a change in pH may play some part, but this was not ascertained. Although the initial pH of the various media ranged from about 3 to 9, when good growth of *R. Solani* was evident, the reaction of the alkaline series changed to the acid side. This development of acid was noted in an experiment where various dyes in different concentrations were added to nutrient agar in Petri plates. In the case of tri-phenyl methane dyes, crystal violet, and malachite green, at low concentrations, the organism decolorized the medium as the mycelium advanced across the surface of the agar. At higher dye concentrations the media became decolorized more slowly and the growth of the organism was impeded. It was assumed that an acid reaction produced by the organism reduced this type of dye to the colourless leuco base. Also, it was noted that sclerotia formation was inhibited by the tri-phenyl methane and the fluorescein groups of dyes. Here the inhibition was directly dependent upon the dye concentration. Although no concentration lower than 1 : 125,000 was employed, it was apparent that some factor related to the molecular structure of these dyes was toxic to *R. Solani*.

Temperature.—Richards (*11*), studying the influence of temperature on the pathogenicity of *R. Solani*, concluded that 18° C. was optimum for tissue destruction of peas, beans and potatoes. Serious destruction of potato tissue occurred at 9° C., but little damage was noted at 24° C.

and above. In pure culture studies he found that the organism grew between 4.6° and 32.6° C., with an optimum for 96 hours at 25° to 27° C.

For determining the effects of temperature on sclerotia, *R. Solani* was incubated in Petri plates at constant temperatures of approximately 6, 10, 15, 18, 21, 25 and 30° C.[3] In some instances the plates remained at the same temperature throughout, while in other cases they were changed from one temperature to another as soon as the fungus had covered the surface of the medium. The data on sclerotia formation were recorded at intervals of about 3 days. It will be noted in Table 3 that the optimum temperature for the production of sclerotia was between 18° and 21° C. At temperatures of 25° to 30° C. sclerotia formation was rapid, but it quickly reached a maximum. Thus a shift from higher temperatures toward optimum in general decreased the rate but increased the ultimate amount, whereas a change from the lower temperatures toward optimum increased both rate and amount.

Atmospheric humidity.—Most authors seem agreed that high humidity is necessary for optimal growth of mycelium and for the development of sclerotia by *R. Solani*. Briton-Jones (*3*) observed that the fungus, on a fresh nutritive medium, formed sclerotia 2 mm. in diameter on the surface, whereas, under desiccation only flabby mycelium or separate groups of sclerotial cells appeared. Park (*10*) showed that the virulence of this fungus increased at the higher humidities. In fact he thought this factor was more important than soil moisture in this respect.

TABLE 3.—PRODUCTION OF SCLEROTIA BY *Rhizoctonia Solani* IN PETRI PLATES AT VARIOUS TEMPERATURES

Number plates	Initial temperature ° C.	Final temperature ° C.	Sclerotia index % days after inoculation					
			12	16	19	22	24	40
10	6	6	0	0	0	0	0	28
10	10	10	0	0	0	5	18	25
18	15	15	0	0	19	36		
10	18	18		49	49	49		
15	15	21	0	15	27	30		
14	15	30	0	23	29	31		
17	21	15	11	42	46			
25	21	21	17	33	37			
10	21	30	21	30	30			
10	25	25		25	26	26		

In the present work *R. Solani* was grown in plate cultures at room temperature until the mycelium extended over the surface of the substrate. The covers were then removed and the plates placed under a large bell-jar in which the atmospheric humidity was controlled by means of super-saturated salt solutions of calcium chloride and ammonium nitrate to give 31 and 60% humidities, respectively, while 100% humidity was obtained by distilled water. Notes were taken before the nutrient agar became desiccated in any treatment.

[3] Use of temperature control chambers was kindly supplied by the Division of Plant Pathology of the Department of Field Crops, University of Alberta.

It appears from the results in Table 4 that the production of sclerotia is somewhat checked at humidities up to or about 60%. Also, it seems that their production is reduced considerably at higher humidities at temperatures of from 25° to 30° C. Sclerotia apparently formed most readily at humidities above 60% and at temperatures below 25° C.—probably between 18° and 21° C. (See Table 3.)

Aeration.—Balls (*1*) and Briton-Jones (*3*) found that oxygen was essential for mycelial growth of *R. Solani*, and Matsumoto (*6* and *7*) that inadequate aeration suppressed the development of sclerotia. The effect of aeration on sclerotia produced by our strain was studied in the following experiment. Fifty 200 cc. Erlenmeyer flasks, each containing 25 cc. of complete nutrient agar, were inoculated, 10 of which were fitted in the usual manner with cotton plugs, and the remaining 40 flasks with tight-fitting rubber stoppers. Ten of these were sealed with wax immediately, another 10 flasks were waxed when the mycelium had covered half the surface of the substrate, 10 flasks were sealed when the fungus had grown over the entire surface of the agar, and the remaining 10 flasks were not sealed with wax.

TABLE 4.—PRODUCTION OF SCLEROTIA BY *Rhizoctonia Solani* AT DIFFERENT DEGREES OF ATMOSPHERIC HUMIDITY DURING 17 DAYS IN PETRI PLATE CULTURE.

Number of plates	Temperature ° C.	Humidity approx. %	Sclerotia index %
12	20–26	31	55
12	20–26	100	62
18	25–30	31	22
35	25–30	60	35
30	25–30	100	36

Nine days after inoculation an abundance of sclerotia appeared in the cotton-plugged flasks, a few sclerotia in the unwaxed ones, and none in any of the flasks the stoppers of which were waxed. However, the mycelium in all the waxed flasks appeared to grow fairly well. At the end of 50 days no sclerotia appeared in any of the waxed containers. Therefore, it was concluded that sclerotia will form readily only when adequate oxygen is available, and that it requires more for the production of sclerotia than for mycelial growth.

Irradiation.—Since there was in the laboratory a supply of natural powdered pitchblende ore, kindly donated to us by the Eldorado Gold Mines for experimental purposes, an opportunity was presented to determine if emanations from it would affect the production of sclerotia. The powdered ore (25 pounds), containing about 30% uranium oxide, was composted with paraffin and the mixture applied in a half inch layer completely covering the inside of a sheet iron box 1 × 2 × 1 feet. An identical box, lined with paraffin mixed with silica sand, was constructed for a control box.[4]

The same complete substrate and technique, used throughout this test, were employed in this experiment. Five separate tests were made during five months, each involving 13 test plates and an equal number of controls. The degree of sclerotia formation was read at the end of ten

[4] This apparatus is being used by Dr. W. C. Broadfoot of this laboratory in connection with another study be reported later.

days. The index of sclerotia in each of the various tests was 36, 33, 23.5, 26.5, and 26%, compared to the controls of 21, 24, 17, 16, and 18%, respectively, with an average of 29% for the irradiated series and 19.2% for the controls.

DISCUSSION

In discussing these results it is clear that without phosphorus and nitrogen, sclerotia are not produced. In the case of phosphorus, about 7.5 p.p.m. was the minimum, and of the nitrogen 50 to 56 p.p.m., the optimum requirements being 31 and 560 p.p.m., respectively. Sclerotia formed fairly readily when a very small trace of potassium or magnesium was available in the medium, the amount being so small that, with the exception of potassium, it was practically impossible to ascertain either the minimal or optimal requirements. Further, sclerotia formed when a trace of either was present, and no striking acceleration was observed, except possibly in the case of potassium. At least, it is clear a trace of each is beneficial for sclerotia formation and more definitely so for mycelial growth.

In considering the problem under field conditions, the availability of phosphorus and nitrogen must be important for optimal sclerotia production, and any environmental factors which make these elements less available should be considered. Few samples of soil will contain as little as 7.5 p.p.m. of available phosphorus. Indeed it appears (Mitchell (*8*) and Doughty (*4*)) that in a relatively large percentage of our prairie soils the available phosphorus lies between 20 and 30 p.p.m., and, therefore, only slightly below the optimum of 31 p.p.m. for sclerotia formation in pure culture. Also, practice of continuous cropping might further reduce the available phosphorus.

In the case of available nitrate nitrogen the minimum of 50 p.p.m. found for sclerotia production in pure culture will seldom be exceeded, or indeed equalled, in average soil samples, and the optimum of 560 p.p.m. would not occur normally in virgin soil. (Wyatt *et al* (12).). Therefore, it would seem possible that the availability of nitrate nitrogen in a given soil at a critical period might be definitely significant with regard to the optimum formation of sclerotia.

With potassium, magnesium and calcium the results observed in pure culture would indicate that sufficient of these elements for optimum sclerotia formation would be present in normal field soil.

Coming to the environmental factors, it would appear that soil temperature and soil moisture are both extremely important in the production of sclerotia under field conditions. Atmospheric humidities above 60% are undoubtedly very favourable, while a humidity below this point is detrimental. Moreover, since soil moisture often varies greatly during any growing season, the effect of such extremes on the availability of mineral elements and on the growth of the pathogen might be marked. With regard to the temperature factor, sclerotia were produced between 6° and 30° C. The optimum was between 18° and 21° C., which temperatures are obviously not uncommon in cultivated soils throughout the temperate latitudes during September and early October. Mycelial growth is also excellent at these temperatures. One has also to consider

the possible effect of alternating high and low daily temperatures of the air and soil. As the season advances and cool nights vary with hot days, the tendency, if the soil is not too dry for the saturation point to be reached, will be to favour the production of sclerotia. It is common observation that sclerotia form more readily late in the season than during summer. Possibly this may be closely associated with the situation in the soil then, with regard to temperature and humidity.

In connection with soil reaction, these studies indicate that sclerotia formation occurs very well within a range of pH values common to normal soils, so this factor probably is not of great importance in the practical problem.

The present studies also showed that sclerotia must have adequate aeration to form normally. Aeration may be insufficient in very moist, heavy soils, but it is doubtful if this would be a limiting factor in soils of average texture under field conditions. Thus, from a practical standpoint, the question of aeration would not seem of sufficient importance to stress. Obviously the effects of irradiation in natural soils cannot be compared to the effects obtained from the pitchblende used.

Finally, the rôle of available carbohydrates in the natural field soil also should be considered in relation to sclerotia formation, but unfortunately data on this phase are not yet available to present in this paper.

SUMMARY

The effect of phosphorus, potassium, nitrogen, magnesium, calcium and sulphur, and certain environmental factors, including the reaction of substrate, temperature, humidity, aeration and irradiation on sclerotia formation by *R. Solani* Kühn, was studied in pure culture, and, where possible, the optimal and minimal unit for each indicated.

Sclerotia were not produced when either phosphorus or nitrogen were absent from the medium. The optimal and minimal units for phosphorus were 31 p.p.m., and 7.5 p.p.m., and for nitrogen 560 p.p.m., and 50–60 p.p.m., respectively. The minimal for potassium was about 2 p.p.m., but the optimal point could not be determined, as sclerotia were produced almost equally well over a wide range of concentrations. Sclerotia were somewhat curtailed at concentrations of magnesium below 20 p.p.m. Small amounts appear beneficial for optimum growth of both sclerotia and mycelium. The omission of calcium from the medium did not affect sclerotia production nor mycelial growth. A concentration of 320 p.p.m. of sulphur completely suppressed sclerotia and reduced mycelial growth.

At pH values between 3 and 9, sclerotia were produced readily, with the optimum around pH 5.5. The optimum temperature for sclerotia appeared to lie between 18 and 21° C., and in this range of temperature the most favourable atmospheric humidity was above 60%. Irradiations from pitchblende increased sclerotia formation.

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ERRATA

In the article entitled "The reaction of Wheat Varieties to Different Dates of Sowing" by J. B. Harrington and W. L. Horner appearing in the November, 1935, issue of Scientific Agriculture on page 127, the following corrections should be made.—

In Table 2, page 129, the first date of sowing should be April 15, and not April 5. In Figure 1 on page 130 in the left-hand margin of the cut, the yield in bushels per acre should read 25, 23, 21, 19, 17, 15 and 30, omitting the zeros which appear after these figures.

THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

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THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, LARGELY FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

Wholesale prices in Canada reached a higher level in October than in any month since April, 1931. The index of vegetable products advanced from 67.2 in September to 68.5; that of animals and their products rose from 72.0 to 73.5. Indexes of fibres, textiles and textile products, non-ferrous metals and their products, and chemicals and their products also registered gains. The index of iron and its products was unchanged, while wood, wood products and paper, and non-metallic minerals and their products were slightly lower. Wholesale prices generally have shown a rather sharp advance since August.

Retail Prices.—Retail prices were also higher in October, the index rising to 80.4. The highest point reached since September, 1932. The index of retail prices of food rose from 70.9 in September to 72.4, and both the fuel and rental indexes were higher than in the previous month. Retail prices appear to have been rising somewhat slowly but steadily since last July.

Physical Volume of Business.—The index of the physical volume of business is available only for the nine months of the year but the monthly index for September was 101.9 compared with 107.9 in August, which was the highest point registered. It will be observed, however, that this index has not been lower than 97.5 which was recorded in January. It is therefore understandable that the high level reached in August should not be maintained in the month of September. The index of industrial production also registered a loss in September, falling to 102.5. Mineral production was also below that of August. In only one group, lead production, was the index higher than in August. Shipments of both gold and silver were materially lower. The index of manufacturing showed relatively less decline, that for August being 102.7 compared with 100.0 in September. In the foodstuffs group there was an actual gain of 6.6 points, one of the interesting developments being a sharp rise in exports of cheese from Canada. Another gain was shown in the iron and steel index which rose from 133.5 to 161.5. The construction index which reached 69.8 in August, the highest point since the beginning of the year, receded to 52.1. Contracts awarded dropped from 82.0 to 59.9. Building permits showed a slight reduction and the cost of construction was little changed. Electric power output was slightly lower. Trade employment showed improvement but car-loadings, exports and imports were lower. Among the Agricultural factors grain and live stock marketings were lower. This was attributable to relatively less grain moving than in the previous month, the index of wheat marketings falling from 202.5 to 128.0. The index of live stock marketings rose from 86.6 to 90.2. This was due to larger shipments of cattle and calves. There was little change in storage holdings compared with the previous month. October indexes added since the foregoing was written show an upturn.

Prices of Agricultural Products.—The index of wholesale prices of Canadian farm products was 65.8 in October. This is the highest point reached since November, 1930. The index of prices of field products advanced from 58.3 to 59.3. Among grains the average price of wheat was only slightly above that in September but prices of rye and flax were substantially higher. Prices of live stock were well above

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION
COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933	67.1	51.0	45.8	59.6	77.7	79.7	76.8	105.1	115.4
1934	71.6	59.0	53.9	67.6	78.9	94.2	93.6	88.5	114.2
1934									
Jan.	70.6	55.3	47.9	67.8	78.2	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	78.7	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	79.9	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.4	92.6	91.4	56.9	94.5
May	71.1	56.9	51.1	66.5	78.5	99.6	99.4	130.6	102.6
June	72.1	59.3	55.5	65.6	78.2	95.8	95.2	97.2	126.1
July	72.0	60.0	57.8	63.7	78.4	95.7	95.6	148.8	116.3
Aug.	72.3	61.6	60.7	63.1	78.7	99.0	99.8	172.8	114.7
Sept.	72.0	61.3	58.9	65.3	79.0	97.1	97.5	127.7	117.7
Oct.	71.4	60.9	55.3	70.4	79.3	95.8	95.3	61.2	128.8
Nov.	71.2	61.2	55.7	70.4	79.4	96.5	97.0	51.2	130.4
Dec.	71.2	61.6	56.0	70.9	79.0	92.4	91.0	36.0	135.7
1935									
Jan.	71.5	61.4	55.7	71.0	78.8	97.5	97.8	30.6	143.7
Feb.	71.9	62.0	55.7	72.6	78.9	100.6	101.1	62.2	141.2
Mar.	72.0	62.7	56.4	73.3	78.8	94.2	93.3	65.4	143.2
Apr.	72.5	64.7	59.8	72.9	78.6	98.3	97.7	91.8	135.8
May	72.3	64.1	58.0	74.4	78.6	103.2	104.4	86.3	123.2
June	71.5	61.4	55.1	72.0	78.8	99.2	99.7	106.1	125.0
July	71.5	61.5	55.7	71.1	78.8	103.0	104.0	164.7	114.8
Aug.	71.6	61.8	55.5	72.4	79.4	107.9	110.3	163.9	117.0
Sept.	72.3	64.7	58.3	76.5	79.6	101.9	102.5	114.2	117.2
Oct.	73.1	65.8	59.3	76.7	80.4	107.2	109.5	86.6	119.7

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.
2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1932, p. 32, and Monthly Mimeographs 1933 and 1934.
3. Wholesale prices of grains, fruits and vegetables.
4. Wholesale prices of Animals and Animal Products.
5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.
Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs, 1933-1934.
6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical Volume of Business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

those secured in September. This was particularly true of prices of calves and lambs. On account of heavy shipments average prices of cattle and hogs were slightly below the average for September. Prices of creamery butter showed a substantial gain and short supplies of eggs resulted in a sharp advance in prices.

Production.—The second crop estimate furnished by the Dominion Bureau of Statistics shows a reduction in the estimate of the wheat crop which is now placed at 273,971,000 bushels compared with 275,849,000 in 1934. Supplies of oats will be substantially above those of 1934 for this crop is estimated at 416,369,000 bushels against 321,120,000 bushels last year. Barley production is placed at 87,512,000 bushels in 1935, an increase of nearly 24 million bushels over the 1934 production. The output of mixed grains will be barely two million bushels higher than a year ago. The production of rye is nearly double that in 1934, being estimated at 10,610,000 bushels. With the exception of wheat and buckwheat yields per acre are higher than was the case last year. The potato crop will be smaller by 19 per cent, the yield this year being estimated at 38,786,000 hundredweight compared with the large crop of 48,095,000 hundredweight last year. Fodder crops have yielded better than in 1934.

Production of creamery butter in Canada during the first ten months of 1935 showed an increase of 1.7%, the largest percentage increases taking place in Quebec, Saskatchewan, Ontario, and Manitoba. Very substantial decreases have occurred in the Maritime Provinces and Alberta, whereas British Columbia shows a minor decline. The total output during this period was 215,449,205 pounds compared with 211,761,044 in the first ten months of 1934. Marketings of live stock reported by the Markets Intelligence Service of the Dominion Live Stock Branch show an increase in the number of cattle sold at public markets during the first 46 weeks of 1935 compared with the sales in the same period of 1934, the respective figures being 734,274 and 614,707. Sales of calves during a similar period were also somewhat higher in 1934. Sales of sheep were 388,697 in 1935 compared with 415,322 in 1934. The number of hogs graded this year was 2,527,161 while in 1934 the number was 2,567,304.

The General Outlook.—The movement of wheat overseas during the early months of the crop year has been comparatively low indicating fairly substantial supplies of European wheat. This is offset to a large extent through shipments to the United States and the fact that selling pressure from Southern Hemisphere countries has not been so marked. Trade restrictions play a large part in international trade and will still be a strong factor in 1936. The indications are that live stock prices will continue to be fairly satisfactory. The farmers' position, though still far from what might be desired has shown distinct improvement during 1935 and the indications are that further improvements may be expected in 1936. A great deal depends on developments in international affairs.

NOTES

The Nova Scotia Royal Commission in its report dated October 24, 1934, strongly recommended that legislation be passed which would give greater opportunities for co-operative organization. In keeping with this recommendation "The Co-operative Associations Act" was passed the 11th day of May, 1935. Its terms apply to any co-operative association incorporated under the Nova Scotia Companies Act for the purpose of marketing or processing products of the farm, forest, and sea, and buying all supplies necessary in the production or marketing of such products. Five per cent of the net profits shall be set aside yearly to establish a Reserve Fund, that is to be kept liquid. At any meeting, each member shall have only one vote.

The Act provides for the appointment of an inspector of co-operative associations. The inspector is given power to examine any book or document and to demand any information he may require. His approval is necessary before the registration of any association and also before any withdrawal may be made from the Reserve Fund. Mr. R. J. MacSween of Antigonish has been appointed Inspector.

The Economics Branch will shortly publish a new bulletin entitled "Farmers' Business Organizations in Canada, 1935," by A. E. Richards. This will be the second summary of Farmers' Business Organizations and their activities to be published by the Branch.

COST OF PRODUCTION RECORDS AND THEIR USE IN AGRICULTURAL PRICE DETERMINATIONS[1]

J. F. Booth[2]

The widespread adoption of price-supporting measures of various types in recent years has increased the interest in, and use of cost of production data. Public and semi-public bodies entrusted with the task of deciding what constitutes a "fair" price have found information on costs valuable, if not essential. They are thus endeavouring to bring to their task the same basic information that the manufacturer uses in determining the price that he will ask for his product. They should, however, recognize that there are certain limitations as well as advantages in the use of such data and that neither manufacturer nor farmer can always sell his product at a price that will cover costs plus profit.

Development of Farm Cost Analysis in United States.—A record of the development of cost of production studies as applied to agriculture is interesting and, when analyzed, has a bearing on our discussion today. A review of agricultural history reveals some interesting observations on costs but the calculation of costs for groups of farms and their use in price determination is a matter of fairly recent origin. Bennett, in his book "Farm Cost Studies in the United States,"[3] gives us a record of the development in that country which, as far as early activities are concerned, was doubtless paralleled in Canada. In discussing the chronological development of both interest and technique he divides the period into two sections with the year 1902 marking the change. Prior to that time data on costs were derived from three sources, first the records kept by individual farmers and published frequently in the farm press of the day to indicate, usually, that a certain product could be grown with profit in a particular area. Some present will remember this era in Western Canada, which however, extended to a later date and was associated with the promotional settlement period of development in that region. The second is represented by the State Experiment Station activities. Of these the author states:—

"The major purpose of such experiments was to ascertain what rations and fertilizers were most satisfactory from a chemical standpoint, but cost data were frequently added in order to demonstrate the relative profitableness of different rations and fertilizers. Such cost statements were not uncommon even before the granting of federal aid to the agricultural experiment stations in 1888 and the subsequent expansion of agricultural research. Between 1888 and 1902 they increased greatly in number, and increasing emphasis was placed on the accuracy and completeness of the cost figures.

"These cost statements compiled by individual farmers or by investigators in the experiment stations were not, however, statistical in nature. Not only were costs given in incomplete form, but they referred either to single farms or to cultivation under experimental conditions. They serve to show that interest in costs of production existed before 1902, and that the interest was growing. They illustrate the prevalence of the fallacious ideas that costs do not vary greatly from farm to farm and from year to year, and that costs obtained from a single farm may be regarded as representative of costs incurred throughout a wide region. Otherwise these cost statements are of no significance."[4]

The third phase of development is represented by a statistical approach that might be termed the forerunner of modern methods. The statistician of the United States Department of Agriculture, as early as 1876, and several of the State Institutions a few years later, began obtaining costs from farmers by the questionnaire method and from correspondents in different countries. In 1897 two farm journals, "The American Agriculturist," and the "Orange Judd Farmer," investigated the cost

[1] A Summary of an Address to the Inter-provincial Conference of Milk Control Boards, Toronto, November 20, 1935.

[2] Commissioner, Agricultural Economics Branch, Department of Agriculture, Ottawa.

[3] Bennett, Merrill K. Farm Cost Studies in the United States. Food Research Institute, Stanford University, California, 1928.

[4] Ibid.

of corn production by inducing "a large number" of farmers to keep day-to-day records on prepared blank forms.[5] The information obtained from these later studies was used to compare the relative profitableness of different farm practices, and during the years of low prices after 1890, to support demands of farmers for remedial measures.

Developments after 1902.—In 1902 Professor Willet M. Hays of the Minnesota Experiment Station in co-operation with the statistician of the United States Department of Agriculture, began a systematic cost inquiry of the type later referred to as the route method.[6] In 1906 the office of Farm Management, United States Department of Agriculture, began cost studies.[7]

Somewhere about the turn of the century Professors L. H. Bailey and John Craig of Cornell University began a number of field studies of horticultural conditions in New York. In 1903 G. F. Warren was assigned to one of these and discovered "that other factors were more important than the soil." He changed the study from a soil survey to a statistical survey.[7] In 1907 labour income records were obtained in two townships of Tompkins county. In 1912 a study of the cost of producing milk was started in Delaware County and repeated in 1913. In the latter year a study of the cost of producing potatoes was made. In these studies a new approach to the analysis of farm problems was introduced, known as the survey method. Credit for the introduction and development of the survey method is generally assigned to Dr. Warren. A great many cost studies were completed throughout the United States during the years 1915-19 and the use of such data in war-time price-control efforts was popular.

Reference will again be made to the route and survey methods but it will suffice to say at this point that these have extended to other countries. In Canada with the introduction of Farm Economics at the Ontario Agricultural College in 1916, both methods were introduced. In England and throughout Europe, particularly in Denmark and Germany where interest in costs has for many years been of major concern, the survey and route methods were added to the "costings" technique.

Cost Studies in Canada.—In 1891 Dr. Wm. Saunders of the Dominion Experimental Farms contributed a bulletin on "Indian Corn or Maize," in one section of which he gave a summary of the cost of producing one acre of ensilage. Other cost data were presented in succeeding years and after 1900 under the leadership of Dr. J. H. Grisdale this field of activity was considerably enlarged.[9] In 1919 the survey method was adopted in a study of farming in Quebec tributary to six illustration stations. The questionnaire method has also been used by the Experimental Farms as a means of obtaining cost data from privately operated farms. Two comprehensive reports on costs of producing farm crops in Eastern and Western Canada have recently been contributed by Dr. E. S. Hopkins and his associates.

The Department of Farm Economics, Ontario Agricultural College, Guelph, used the survey method in determining the cost of producing milk in Oxford County in 1917. The Book method was introduced in Ontario in 1920. In British Columbia Professor H. R. Hare used the Survey method to determine the costs of producing milk over a ten-year period. Dr. E. Misner employed similar methods in his study of dairy production costs in Saskatchewan in 1928. In Quebec the Rural Economics Service and the Department of Farm Economics, Macdonald College obtained costs on dairy farms during the period 1929 to 1934. Dr. Wm. Allen of the University of Saskatchewan has also conducted cost accounting studies by the survey method in areas in which wheat-growing is the predominant type of farming. Generally speaking, however, relatively little has been done in Canada in cost analysis as far as agriculture is concerned.

[5] Ibid. As reported in "The Book of Corn" by Myrick and others, in Chapter XV; "Cost of Corn Production," by B. W. Snow.
[6] Ibid.
[7] Peck, F. W. Methods of Conducting Cost of Production and Farm Organization Studies. U.S. Dep of Agriculture. Bulletin 994. 1921.[9]
[8] Warren, G. F. Agricultural Surveys, Cornell Agricultural Experiment Station, Bulletin 344, 1914
[9] Unpublished data and correspondence E. S. Hopkins, Central Experimental Farm, Ottawa.

Factors Responsible for Interest.—One of the purposes in thus reviewing the development of cost analysis is to indicate the factors responsible for the interest in this matter. Briefly it may be said that the early cost records were of the type associated with the development of a new area and the introduction of new crops where individuals kept accounts to compare with costs in areas from which they or the product tested originated. During the depression of the period 1890–97 with very low prices prevailing costs were obtained and published to indicate the unfavourable position of farming. After 1900 the collection of costs became associated with farm accounting and the development of the survey method of studying the farm business. Under this stimulus a great development occurred and has been continued. Out of this has grown the science of farm management.

The interest in price-fixing measures during the world war period of rising prices encouraged the use of cost of production records and this interest has again been aroused during recent years of declining prices. If legislative price-fixing remains with us, the interest in cost records will probably continue. Summarizing this development it is apparent that serious price maladjustments have greatly stimulated the interest in costs but the thing that has contributed most toward the permanent support of such work is the use of the results in studying the farm as a business enterprise.

Consideration of Methods.—From a consideration of the development of cost analysis we turn next to a description of the methods referred to. These will be referred to as (1) the accounting method, which includes the route plan already mentioned; (2) the survey method; and (3) the experimental farms method.

Where detailed records are desired and where the farmer has the necessary time and patience to devote to the task a complete cost accounting system may be established. This involves a double entry system with journal and ledger and requires not only the accurate recording of all receipts and expenditures by particular crop and live stock enterprises but also labour records for men and for horses or tractor. It means that the time taken for each field operation and for each activity associated with the handling of live stock must be recorded. It means the allocation of overhead costs—of charges for the use of land, buildings, and equipment, and interest to each enterprise. It means the determination of the cost of feed that is fed to live stock. In other words it is a complete record of the operations of the farm and of every single enterprise.

Records so kept are, of course, the most satisfactory but they are so detailed and involved that relatively few farmers will undertake to keep them—and keep their undertaking—for long. The recording of costs is not the only purpose of such an accounting system, or perhaps one should say, that the determination of costs is usually considered incidental to the analysis of farming operations. Notwithstanding the fact that such records contain many estimates the results offer a splendid opportunity for the study of the relative advantages of different enterprises and the most successful combination of enterprises in a farm business. For this reason many colleges of agriculture encourage and even assist farmers to keep such records. In the United States, in Great Britain and, in a small way in Canada, agricultural officials at state institutions assist farmers in establishing farm accounting systems and in "closing" the books annually. In some instances, as already indicated, routes are established with an accountant in charge of a considerable number of accounts. In other cases books are opened and an occasional visit duirng the year is made by the representative of the college to check results.

Recognizing the value of such accounts and of the advice given by an independent authority on farm management (the accountant usually being an agricultural economist or a specialist in farm management) farmers in some instances contribute to the cost of the service. The Agricultural Economics Departments of our Agricultural Colleges always encourage cost accounting, for in addition to its value to the individuals whose operations are analysed, such records provide valuable information for teaching and extension work.

Accounts kept on such a basis are perhaps the most satisfactory source of cost data but until we have more trained agricultural accountants at our colleges of Agriculture in Canada to assist farmers with this method, the number of accounts available for analysis is likely to be very limited.

A second method involving the keeping of more or less regular accounts, but nothing like as involved as that just described, consists of the keeping of a simple record of expenditures and receipts and a detailed cost account record for the principle enterprise. A third modification and one that might be considered by milk boards or co-operative agencies desirous of ascertaining production costs in their areas, consists of a simple enterprise account. This consists of a beginning and ending inventory, a financial record of charges against cows, a record of credits, and a work record for man labour, horses, trucks, etc.

The Survey Method.—Because of the detail involved in the keeping of farm accounts and for that reason the difficulty of getting farmers to keep such accounts, another method has been devised and is widely used by agricultural economists and others desirous of studying the farm business or of obtaining farm costs. Again, as in the keeping of cost accounts, the primary purpose of this method is to enable the farmer to analyse his own business and, since a survey usually includes a considerable number of farms, to enable comparisons to be made with other farms in the same area. Frequently such surveys are designed to obtain the farmers "labour income" which by some economists is considered the best single measure of farm efficiency. Additional data may be obtained in order to enable the calculation of costs of production of the major product, milk or wheat for instance, is determined by the simple process of considering that side-line or minor enterprises cost approximately what they return and the balance of the expense is chargeable to the major enterprise. This method, although frequently used because of its simplicity, is only practicable where the major enterprise is predominantly the object of expenditure and source of expenditure and source of income.

The survey method may also be used to determine the cost of a single enterprise. In such cases a much less detailed survey form is used—other phases of the farm business being omitted.

The procedure involved in the survey method is relatively simple and results can be obtained with reasonable dispatch and accuracy. A questionnaire of more or less standard form is used. The enumerator visits the farmer and obtains from him a record of his farm operations for the past year including receipts and expenditures. Records where available are used, otherwise the farmer's memory and his ability to estimate accurately are made use of. Fortunately on most farms the number of financial transactions is limited and of such proportions and importance that farmers can easily remember them. Questioned systemmatically, one operation at a time, by an enumerator who understands farming, most farmers can give a surprisingly good record of financial transactions. Averages from a number of such records check surprisingly well with recorded facts. The taking of such a record may require anywhere from an hour to three or four hours but it will at once be appreciated that in the course of several weeks two or three men can obtain information from a hundred or more farms. Although the analysis of the data thus obtained may require several weeks or several months, depending upon how much detail is involved, the whole operation can be completed in a much shorter time than is required where the cost account method is followed.

Experimental Farm Cost Studies.—Reference has already been made to the methods adopted by the Dominion Experimental Farms in obtaining cost records. Limited use has been made of the survey and questionnaire methods but most results have been obtained from cost computations of data obtained in experimental work. Most of these studies have been conducted on the Central Farm at Ottawa and at branch farms and stations throughout Canada. In a number of instances data have also been obtained on illustration farms which are operated by individual farms under supervision.

Other Methods.—The mail questionnaire has been used in obtaining costs on quite an extensive scale but it is limited to rather simple studies or instances where supplementary data are required. In a number of cases correspondents have sent in returns regularly. The United States Department of Agriculture pursued this course for some years but eventually abandoned the policy. Here, too, there is a definite limit to the information which can be secured and generally speaking, this plan must be used in association with one of the other systems to obtain supplementary current data.

Costs in Succeeding Years.—Having obtained a record of the cost of producing a product for a given year, either by the accounting or survey method, the cost for several additional years may be calculated. This, of course, requires a careful recording of the "input" factors, i.e., the number of hours of man labour and horse labour, the number of pounds, bushels, or tons of various feeds consumed, the proportion of the valuation of land, buildings, and equipment used. With the quantitative factors known, the valuations and prices of succeeding years can be applied. Obviously, however, there is a limit to the number of years that costs can be constructed on a single year's basic data for in time the quantitative factors themselves change. In other words farming methods change and the quantity of land, labour and capital consumed in a single productive operation changes.

Use of Cost Data.—Having considered some of the methods of obtaining cost of production data, let us now turn to the use of such information. In this connection it might be well to consider the limitations involved. These may be divided roughly into two classes, first those concerning the data themselves and second, the application of the data to the problem. Concerning the first it may be said that there are differences of opinion among accountants and economists as to the reliability of cost data. The fact that estimates must be used, that costs must be divided between enterprises disturbs some people. The question of whether to use a simple average, a weighted average, a bulk-line cost or a device such as the median or the modal cost, is always the occasion for discussion. What to include among costs is always a subject of debate. Authorities disagree on whether interest and rent should be charged and if so, on what basis. Critics who would not think of questioning the accounts of any other business that included charges for depreciation, interest, rent, family, and operator's or manager's labour, object to the inclusion of these items in farm accounts. When labour income records are low, or when costs are higher than prices they point to the fact that farmers continue to operate their farms and therefore something must be wrong with the records. They fail, of course, to differentiate between short and long time costs—fail to realize that a farmer may continue for some years without covering all costs, that he can wear out his buildings and equipment, forego interest on his investment or receive no return for his labour, but that over a long period of years these costs must be met. To satisfy those who do not think farmers should charge all costs, the Economics Branch and some other agencies calculate results on several bases.

Application to Price Determination.—With regard to the application of cost data to price determination a number of factors should be considered. Generally speaking, price fixing must be considered in terms of future costs. Once a product has been produced it must be sold for what it will bring in competition with other products. Not even price-determining bodies with legislative authority can alter this fundamental concept except perhaps for short periods or under unusual circumstances. Cost data may, however, be useful to such bodies in deciding upon a price that will insure the maximum degree of stability in volume of output and quantity of production.

Reference has already been made to the difficulty of deciding what cost figure to use in price-determination. Perhaps it may be of interest to enlarge upon this. What figure will insure production of the quantity desired? How can over-production be avoided? Can a milk board or price committee dependent upon the support of producers to keep them in office, agree upon a price that will not lead to over-produc-

tion? A price based on average costs will be less than the costs of from 25 to 35 per cent of the producers. Will there not be an irresistible tendency for this reason to decide upon a price that is too high and which will increase the surplus problem? A careful consideration of these possibilities suggests that, in the interests of both producer and consumer, bodies endowed with price-fixing powers should represent all interests and should be appointed on such a basis and for such a period as to insure continuity and independence of action.

Conclusions.—In a brief review of this nature it is, of course, impossible to deal adequately with the subject under discussion. Nothing more than a sketchy analysis can be attempted and doubtless many factors of interest have been omitted. In examining the literature on farm cost accounting and of efforts to use cost of production information as a basis for fixing prices, one observes evidence of a changing viewpoint. Early efforts to use such material were based upon the belief that prices could be determined and adjusted on some formulae basis—that having determined the cost of production the price could be set at that definite figure. Subsequent developments frequently indicated the fallacy of such a policy. In more recent years particularly, with the development and interest in "administrative" prices and the search for some basis for determining such prices, the use of cost data as an *aid* in this connection has received consideration. It is in this sense that cost data should prove of real value. Taken in conjunction with available information on unemployment conditions, factory payrolls, car loadings, bank clearings, indexes of business activity, price trends, and other evidences of economic conditions, data on cost of production can be used to advantage.

Representatives of producers acting as members of boards or committees, or appearing before such bodies in connection with price agreements, should find their case more easily presented and their requests more favourably considered, if their representations are accompanied by reliable data on costs of production.

ECONOMIC LITERATURE

WAITE, C. WARREN, and COX, REX W. A Study of the Consumption of Dairy Products in Minneapolis, 1934, Bulletin 311, University of Minnesota, Agricultural Experimental Stations.

This study was undertaken with the purpose of determining the variations in the rates of consumption of the different dairy products by families in Minneapolis and to account for the differences in these rates. Information was obtained from 2,187 families, which included 8,783 persons. Per capita consumption of dairy products was as follows:—milk 0.85 pint per day, light cream equivalent 0.72 one-half pint per week, butter 0.65 pound per week, cheese 0.49 pound per month, evaporated and condensed milk 0.71 pound per month and ice cream 0.29 quart per month.

The writers state in conclusion that consumption of dairy products in Minneapolis is high in relation to consumption in eastern cities and say this is probably so because of its location in the heart of an important dairy region where the importance of dairy products as an item of food is generally recognized and their retail prices are relatively low. The people are principally of Scandinavian origin and such people usually consume a large quantity of dairy products. In general, the lower-income groups spend a larger portion of their total food expenditures on dairy products, although the per capita expenditure is less than the high-income groups. Increases in income may be expected to increase materially the fluid milk and butter consumption on the low-income group; increase butter consumption slightly, cream consumption a great deal, and fluid milk slightly in the medium-income group, and change consumption hardly at all in the higher-income group. The relationships found between income and the rate of consumption of various dairy products indicate the dependence of the prosperity of the dairy industry upon an increase in the incomes of the low and middle class groups in the cities.

FINANCIAL STATEMENTS

W. F. Chown[1]

The profit or loss resulting from the operation of a business can be determined by comparing the Net Worth shown in Statements of Assets and Liabilities prepared at the beginning and end of the financial period, subject to adjustment for additions or withdrawals of capital. To explain how the profit was earned or loss sustained another form of statement should be prepared which is called variously Income and Expense, Revenue and Expenditure, Operating, Profit and Loss. This statement can be constructed in several sections and in a variety of forms to meet different requirements.

The preparation of this statement necessitates a complete set of double-entry accounts or the completion of single entry records at the end of the financial period. It is impossible to cover the subject fully in this article but some discussion of the principles involved with an illustration of a simple case may be of value.

Double entry theory recognizes the two-sidedness of every business transaction, value received and value given. When a farmer sells a cow for $80 cash, he receives value, $80, and gives value, a cow. An account is a page in the ledger on which are assembled values of a similar kind arising from like transactions. In recording the above transaction Cash Account is debited and Livestock Sales Account credited. For every debit there must be a corresponding credit. An implement dealer may have rows of bins in his stock room with repairs of a like kind in each and the kind denoted by a number marked on the bin. So in the ledger values of the same kind can be sorted into the different accounts each of which is given an appropriate title. The values are moved in and out by means of debit and credit entries.

Trial Balance.—Because there must be a credit entry for every debit, and vice versa, the accounts can be proved arithmetically. To do this, the accounts are listed and the balances shown in two columns, debit and credit. The totals of these columns agree if the accounts have been correctly kept. This summary of ledger balances is called a Trial Balance.

THOMAS BROWN
Trial Balance
April 1, 1934

	Dr.	Cr.
Cash	$ 625.00	
Accounts Receivable	83.00	
Land	6,000.00	
Buildings	6,000.00	
Reserve for Depreciation of Buildings		$ 2,160.00
Machinery and Equipment	1,630.00	
Reserve for Depreciation Machinery and Equipment		720.00
Cattle	900.00	
Horses	450.00	
Hogs	25.00	
Feed and Seed	150.00	
Prepaid Insurance	80.00	
Accounts Payable		210.00
Interest Payable		240.00
Mortgage Payable.		4,000.00
Surplus		8,613.00
	$15,943.00	$15,943.00

To assist in the sorting, entries are first made in a book of Original Entry, e.g., General Journal, Cash Book, etc. The Columnar Cash Book described in the September issue of the ***Economic Annalist*** illustrates how this may be done. After the totals of the special columns and the individual items in the sundry column have

[1] Account Examiner, Economics Branch, Department of Agriculture, Ottawa.

been posted to Thomas Brown's General Ledger, the trial balance would show as in Columns 1 and 2 in the accompanying working sheet.

General Journal.—At the end of a financial period adjustments must be made in the accounts for changes other than cash. Inventories must be taken. The portion of each type of value (assets) carried on the books that has been consumed and that remains must be determined. Accounts Receivable must be debited for amounts due to Brown, and Sales credited. The liability for Accounts Payable must be set up and the proper account charged or debited. In this case where only cash entries have been made during the year, Accounts Receivable and Payable will have to be adjusted for the beginning of the year. It will also be necessary to debit a Depreciation expense account and credit Reserve for Depreciation for the value of plant consumed during the years operations. These adjusting entries are made in the General Journal which is ruled with two columns to the right of the page, the left hand column is debit, the right hand column credit.

Journal entries illustrating these adjustments follow and are also shown in columns 3 and 4 in the working sheet.

GENERAL JOURNAL

		Dr.	Cr.
1935		$	$
March 31	Milk Sales	80.00	
	Cream Sales	3.00	
	Accounts Receivable		83.00
	To adjust Accounts Receivable April 1, 1934		
	Accounts Payable	210.00	
	Machinery Note Payable		80.00
	Wages		120.00
	Milk Cartage		10.00
	To adjust Accounts Payable April 1, 1934		
	Accounts Receivable	182.00	
	Milk Sales		182.00
	To set up Milk Cheque Receivable March 31, 1935		
	Milk Cartage	12.00	
	Wages	60.00	
	Feed and Seed	28.00	
	Accounts Payable		100.00
	To charge expenses incurred but unpaid March 31, 1935		
	Depreciation	420.00	
	Reserve for Depreciation Buildings		240.00
	Reserve for Depreciation Machinery and Equipment		180.00
	To charge Depreciation on Buildings at 4%		
	To charge Depreciation on Machinery and Equipment at 10%		
	Insurance	15.00	
	Prepaid Insurance		15.00
	To adjust value of insurance consumed		

Closing the Books.—It now remains (1) to charge Profit and Loss with the value of the opening inventories, (2) to bring into account the new inventories and credit Profit and Loss with them, and (3) to transfer values in income and expense accounts—nominal accounts—to Profit and Loss. This is done by the Journal Entries shown in Columns 7 and 8 on the working sheet. Finally the Profit for the year is carried to Surplus Account. It is now possible to prepare the Balance Sheet shown in the June issue of the ***Economic Annalist.*** The Profit and Loss Account, about as it would appear in the Ledger, follows.

THOMAS BROWN

PROFIT AND LOSS ACCOUNT

FOR THE YEAR ENDING MARCH 31, 1934

Dr.		Cr.	
	$		$
Inventories April 1, 1935—		Sales—	
Livestock	1,375.00	Milk	1,202.00
Feed and Seed	150.00	Cream	52.00
		Eggs	65.00
Purchases—		Livestock	250.00
Horses	150.00	Crops	180.00
Feed and Seed	248.00		
Fertilizer	40.00	Sundry Income	75.00
		Inventories March 31, 1935	
Expenses—		Livestock	1,785.00
Wages	746.00	Feed and Seed	410.00
Repairs	43.00		
Milk Cartage	196.10		
Harvest Expense	65.00		
Insurance	45.00		
Taxes	150.00		
Interest	240.00		
Phone	20.00		
Depreciation	420.00		
Sundry	107.40		
Profit for the year	23.50		
	$4,019.00		$4,019.00

SURPLUS ACCOUNT

Balance, March 31, 1935		Balance, April 1, 1934	8,613.00
Carried to Balance Sheet	8,636.50	Profit for year	23.50
	$8,636.50		$8,636.50

(*Continued on Page 61*)

The services which the wholesalers and jobbers render in the field of marketing are regarded as essential. If these established agencies do not perform the distributing service, then the farmer or co-operative must. Such services include assembling, usually from distant points, large quantities of a wide variety of goods from a fluctuating and seasonal supply. The products must then be stored, sorted as to grade and spread out among consumers according to demand. Business relationships must be established and held with retailers. Personal contact is necessary in order to settle misunderstandings, complaints and claims. Whoever is carrying out the jobbing service must be prepared to extend a long line of credit to retailers who are usually slow to pay. As farmers want cash the credit difficulty is a problem which must be faced. The economical method of shipping from country points is in car lots. Most retailers cannot handle goods in such quantity. Their aim is a rapid turnover with the least amount of stock on hand.

Farmers' co-operatives can and do perform certain of the middleman's services and the extent to which they engage in such activity varies with different commodities. Frequently, however, there is a disposition to underestimate the extent and cost of the services performed in distributing farm produce. Before entering this field, an association is well advised to analyse the situation very carefully in order to be certain that existing agencies are not performing efficiently.

(*Continued from page 60*)

THOMAS BROWN—WORKING SHEET—MARCH 31, 1935

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Trial Balance March 31, 1935		Adjusting Journal Entries		Adjusted Trial Balance		Closing Journal Entries		Final Trial Balance	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.	Dr.	Cr	Dr.	Cr.
	$	$	$	$	$	$	$	$	$	$
Cash	114.50				114.50				114.50	
Accounts Receivable	83.00		182.00	83.00	182.00				182.00	
Land	6,000.00				6,000.00				6,000.00	
Buildings	6,000.00				6,000.00				6,000.00	
Reserve for Depreciation—Buildings		2,160.00		240.00		2,400.00				2,400.00
Machinery and Equipment	1,800.00				1,800.00				1,800.00	
Reserve for Depreciation—Machinery		720.00		180.00		900.00				900.00
Cattle	900.00				900.00		1,000.00	900.00	1,000.00	
Horses	450.00				450.00		600.00	450.00	600.00	
Hogs	25.00				25.00		185.00	25.00	185.00	
Feed and Seed	150.00				150.00		410.00	150.00	410.00	
Prepaid Insurance	80.00			15.00	65.00				65.00	
Accounts Payable		210.00	210.00	100.00		100.00				100.00
Machinery Note Payable				80.00		80.00				80.00
Interest Payable		240.00				240.00				240.00
Mortgage Payable		4,000.00				4,000.00				4,000.00
Surplus		8,613.00				8,613.00				8,613.00
Profit and Loss							3,995.50	4,019.00		23.50
Sales Milk		1,100.00	80.00	182.00		1,202.00	1,202.00			
Sales Cream		55.00	3.00			52.00	52.00			
Sales Eggs		65.00				65.00	65.00			
Sales Livestock		250.00				250.00	250.00			
Sales Crops		180.00				180.00	180.00			
Sundry Income		75.00				75.00	75.00			
Purchases Livestock	150.00				150.00			150.00		
Purchases Feed and Seed	220.00		28.00		248.00			248.00		
Purchases Fertilizer	40.00				40.00			40.00		
Wages	806.00		60.00	120.00	746.00			746.00		
Repairs	43.00				43.00			43.00		
Milk Cartage	194.10		12.00	10.00	196.10			196.10		
Harvest Expense	65.00				65.00			65.00		
Insurance	30.00		15.00		45.00			45.00		
Taxes	150.00				150.00			150.00		
Interest	240.00				240.00			240.00		
Phone	20.00				20.00			20.00		
Depreciation			420.00		420.00			420.00		
Sundry Expense	107.40				107.40			107.40		
	17,668.00	17,668.00	1,010.00	1,010.00	18,157.00	18,157.00	8,014.50	8,014.50	16,356.50	16,356.50

A COMPARISON IN FARM EFFICIENCY[1]

S. C. HUDSON[2]

The importance of the various factors which are associated with greater returns from farming can be demonstrated effectively by a comparison of the organization and returns of the most profitable and the least profitable farms (Table 1). In each area studied, ten farms having the highest average labour income for the three years 1929–1931 were selected as being the most profitable group and ten farms having the lowest average labour income for the same period as the least profitable group.

In comparing the two groups of farms for each of the three areas, little difference in general organization is discernible. In Nova Scotia and Ontario, the proportion of the gross receipts which apples accounted for was almost the same for the two groups.

TABLE 1.—A COMPARISON OF THE TEN MOST PROFITABLE AND THE TEN LEAST PROFITABLE APPLE FARMS IN NOVA SCOTIA, QUEBEC AND ONTARIO FOR THE THREE YEAR PERIOD 1929–1931

	Nova Scotia		Quebec		Ontario	
	10 most profitable farms	10 least profitable farms	10 most profitable farms	10 least profitable farms	10 most profitable farms	10 least profitable farms
	$	$	$	$	$	$
Farm Investment						
Real estate	14,780	24,629	18,685	21,154	19,177	19,682
Machinery and equipment	1,794	2,581	1,384	1,945	2,045	1,624
Live stock	1,491	1,622	666	1,236	638	1,148
Feed and supplies	123	132	148	107	170	127
Total	18,188	28,964	20,883	24,442	22,030	22,581
Farm Receipts						
Apples	5,417	4,175	4,622	1,947	5,508	2,082
Other crops	476	437	194	461	2,082	412
Live stock	1,443	1,023	237	766	341	387
Miscellaneous	189	225	115	147	44	22
Inventory increase	236	397	123	131	226	122
Total	7,761	6,257	5,291	3,452	8,201	3,025
Farm Expenses						
Current expenditures	4,885	5,585	2,189	2,481	4,488	2,732
Capital expenditures	261	405	126	182	319	111
Inventory decrease	514	605	363	522	388	503
Total	5,660	6,595	2,678	3,185	5,195	3,346
Farm income	2,101	−338	2,613	267	3,006	−321
Interest on investment	910	1,448	1,044	1,222	1,102	1,129
Labour income	1,191	−1,786	1,569	−955	1,904	−1,450
Per cent of receipts from apples	69.8	66.7	87.4	56.4	67.2	68.8
Size of orchard (ac. bear.)	27.4	38.8	23.4	15.7	30.2	25.8
Apple receipts per acre	197.72	107.60	197.39	123.75	182.38	80.82
Apple yield per acre	100.5	61.3	64.4	45.5	64.8	33.8
Fertilizer per acre bear. orchard	10.89	9.92	9.70	7.37	4.82	3.05
Average price per bbl. apples sold	1.97	1.75	3.06	2.72	2.81	2.39
Spray material per acre bear. orch.	12.20	8.59	4.58	4.58	7.58	4.80
No. years for receipts to equal capital	2.3	4.6	3.9	7.1	2.7	7.5
Gross receipts per dollar of current expense	1.44	1.01	2.07	1.15	1.68	0.94

[1] The data on which Table 1 is based were secured in a study of apple production in Nova Scotia, Quebec and Ontario, 1929–31. This study was conducted by the Economics Branch in co-operation with the Economics Divisions in the provincial Departments of Agriculture or Colleges of Agriculture.

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In Quebec, however, the more profitable group of farms obtained 87 per cent of their gross receipts from apples while the less fortunate group derived only 56 per cent of their income from this source. It will be noticed that the average price received per barrel in Quebec was much higher than in the other provinces. This probably affected the degree of profitable specialization in apple production. The size of business as measured by the farm investment was found to be greatest for the least profitable groups. Interest constituted a larger charge against these farms. The acreage in bearing orchard, however, was greatest for the most profitable group in the case of Quebec and Ontario while in Nova Scotia the acreage in bearing orchard in the less successful group was greater.

One of the most striking differences between the most profitable and the least profitable groups is in apple receipts per acre of bearing orchard. This item was $90 higher for the former group in Nova Scotia, $74 in Quebec and $100 in Ontario. This difference is due to two factors—yield per acre and price per barrel of apples sold.

The average per acre yield of apples obtained on the more profitable farms was consistently higher than that for the less profitable groups. The group average yield was respectively 100.5 and 61.3 barrels per acre of bearing orchard for Nova Scotia, 64.4 and 45.5 barrels per acre for Quebec and 64.8 and 33.8 barrels per acre for Ontario. Associated with the higher yield in the more successful groups was a higher expenditure for fertilizer per acre of bearing orchard.

The average price per barrel of apples sold was likewise consistently higher for the more profitable groups. The apples produced on the more successful farms, therefore, must be of a higher quality and more effectively marketed. One of the principal factors making for a high degree of quality is thoroughness of spraying. In Nova Scotia and Ontario, the expenditure for spray and dust material per acre of bearing orchard was materially higher for the more profitable groups of farms. In Quebec, the amount spent for spray and dust material per acre of bearing orchard was the same for both groups.

Examining the rate of capital turnover or the number of years required for the farm receipts to equal the farm capital which is the most dependable measure of efficiency in the use of capital one finds that the rate of turnover is much more rapid for the more successful group.

ECONOMIC LITERATURE

POND, G. A., RANNEY, W. P., CRICKMAN, C. W. Factors Causing Variations in Earnings Among Dairy Farmers in Southeastern Minnesota, Bulletin 314, University of Minnesota, University Farm, St. Paul, United States Bureau of Agricultural Economics co-operating.

The purpose of this study, as indicated by the title, is to analyse some of the major factors causing variations in incomes among dairy farmers in Southeastern Minnestota and to point out the extent to which they are the result of differences in practices or methods of management within the control of the individual farm operator. Later studies will deal with crop and live stock practices, the efficiency of labour and machinery and the control of expense.

The results in this bulletin are based on details from 766 yearly farm records, 124 to 180 dairy farm businesses being studied for each year from 1928 to 1932.

The average operator's labour earnings were as follows:—1928, $1,260; 1929, $1,833; 1930, $211; 1931, $650; and 1932, $797. Some farmers had consistently high or consistently low earnings, whereas others varied widely in their relative rankings from year to year. The following eight organization and management factors were found to be associated with earnings:—1. Size of business, 2. Choice of crops; 3. Amount of live stock per 100 acres; 4. Crop yields; 5. Butterfat production per cow; 6. Returns over feed from live stock other than cows; 7. Labour efficiency; and 8. Power, machinery and improvement expense per productive man work unit.

Productive man work units were selected as the most satisfactory measure of size. Crop yields and labour efficiency were higher in the large business units, but

butterfat production per cow was lower. Power and machinery costs per unit of work were lower on the larger farms. In 1928 and 1929, when prices were relatively favourable earnings increased with increases in the size of business unit, but in 1931 and 1932, the opposite trend was observed.

Earnings increased with increases in the index of crop selection, but these increases were somewhat irregular during 1930 to 1932. Intensive live stock production was associated with high crop yields and a high index of crop selection. Many other important relationships between earnings and management factors are described in this bulletin. As well as showing the individual effect of each factor on earnings, the cumulative effect is also brought out. For each additional factor in which a farmer attained better than average accomplishment, there was an increase in earnings of nearly $300.

NOTES

The Agricultural Situation and Outlook for 1936 will be published jointly by the Department of Agriculture and the Department of Trade and Commerce. As in the previous two years, this report will summarize the conditions of supply of, demand for, and competition in, agricultural products, and thus provide a basis for production and marketing policies during the ensuing year. Copies of this publication will be available after the first week of January from the Publicity and Extension Branch, Department of Agriculture, Ottawa.

Mr. F. W. Chown, Economics Branch, Department of Agriculture, Ottawa, has gone to Nova Scotia to assist in completing a study of agricultural conditions in Antigonish County. While in Nova Scotia, Mr. Chown will also visit a number of apple warehouses in the Annapolis Valley to obtain information respecting prices secured for various grades and varieties of apples shipped overseas. The latter project is one in which factors affecting prices of apples are being studied.

The Economics Branch of the Dominion Department of Agriculture in co-operation with the Dairy Branch has completed the field work for a study of consumer demand for milk and cheese in Quebec City, Oshawa, Ontario, and Calgary, Alberta. Approximately three thousand records have been obtained. In Quebec City, the Rural Economics Service assisted in securing the information from consumers.

In the legislation arising from the Price Spreads Investigation a section was added to the Criminal Code whereby it was made an offence for any person engaged in commerce or industry to discriminate in any sale against competitors of the purchaser by granting rebates or discounts not available to such competitors. However, it was stipulated that the provision should not prevent a co-operative society of producers or consumers, or a co-operative wholesale society, returning to its members dividends on their purchases from the society or on their sales to it.

The British Columbia Tree Fruit Marketing Board has announced that Cockfield, Brown and Co., a Canadian advertising organization has been employed to make a study of marketing tree fruits. The present survey will include only the domestic markets—"We are really laying the foundation for the merchandising of our 1936 crop," said G. A. Barrat of the Tree Fruit Board in announcing the plan.

The American Farm Economics Association will hold its twenty-sixth annual meeting in New York from December 27th to 30th. During the sessions, the headquarters of the Association will be at the Hotel Commodore.